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Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXVI.—No. 3008.] *LONDON: FRIDAY, AUGUST* 24, 1923. [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

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See advertisement page 18.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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See Advertisement last week, page 86.

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Specification and Workmanship equal to Main Line Locomotives.
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See page 17. 1134

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Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
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See Advertisement, page 71, Aug. 17.

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SHALLOW DRAFT VESSELS. 1562

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MANNING, WARDLE AND COMPANY, LIMITED,
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AND
Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW - BIRMINGHAM - LONDON.
See Advertisement, page 85. 1111

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PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 53, Aug. 17.

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Including Machine Moulded GEAR WHEELS up to 10 feet dia.;
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IRON CASTINGS up to 15 tons each, in Loam, Dry or Green Sand;
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See Full Page Advt., page 60, Aug. 17.

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D.B.S. GEARS
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Makers of
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Combined Circulating and Air Pumps.
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&c., &c. 1586

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QUEEN'S WHARF, HAMMERSMITH, W.
Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
LATHE WORK up to 10 ft. diameter.
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See half-page Advertisement, page 70, Aug. 3.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: C. E. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

The Yarrow Scholarships.

The COUNCIL of the INSTITUTION OF CIVIL ENGINEERS are PREPARED to CONSIDER APPLICATIONS for NOMINATIONS to the above SCHOLARSHIPS.

These should be submitted before the 1st October, 1923, to the SECRETARY of the Institution, at Great George Street, Westminster, S.W. 1, from whom the detailed regulations may be had on application.

The Yarrow Scholars must be British subjects who, desiring to become Engineers, lack sufficient means to enable them to pursue their practical or scientific training.

The Scholarships are of a value varying from £50-£100 per annum. B 162

Borough Polytechnic Institute,

Borough Road, London, S.E. 1.

ENGINEERING DEPARTMENT.

Under the direction of Geo. E. Draycott, Wh. Ex., A.M.I.M.E.

REINFORCED CONCRETE DESIGN
(Lectures and Drawing Office Work).

By Stanley Vaughan, B.Sc. (Hons. Eng.), A.M.I.C.E.
Thursday, 7.15 to 9.45 p.m.
Commencing on September 28th, 1923.

Note:—This forms part of the Fifth Year's work of the Recognised Course in Structural Engineering for the National Certificate, but qualified non-course students may be admitted upon application to the Head of the Department or to
J. W. BISPHAM, O.B.E., M.A., B.Sc.
(Principal.) B 383

The Polytechnic, 309, Regent Street, W.1.

A SPECIAL COURSE has been arranged for students taking the Studentship Examination of the Institution of Mechanical Engineers, the Preliminary Examination of the Institution of Civil Engineers, and the Final Examination of the Institution of Electrical Engineers (Part 1).

The classes are as follows:—

PURE MATHEMATICS	Monday,	8.0.—9.30.
ENGLISH - - -	,,	6.30.—8.0.
MECHANICS - -	Thursday,	8.0.—9.30.
FRENCH - - -	,,	6.30.—8.0.
PHYSICS - - -	Wednesday,	6.30.—9.0.

The Syllabus covers all the work in these subjects required for the examinations mentioned.

Fee for the Course, £2 2s.

Prospectus free on application to the DIRECTOR OF EDUCATION. B 380

The Polytechnic, 309, Regent St., W.1.

SCHOOL OF ENGINEERING.

President of the School:
The Hon. SIR CHARLES PARSONS, K.C.B., M.A., LL.D., D.Sc., F.R.S., &c.
Head of Department:
ALEX. R. HORNE, O.B.E., B.Sc. (Hons. Eng.), F.R.S. (Edin.), &c.

The DAY DEPARTMENT re-opens on SEPTEMBER 18th, 1923. Entrance Examination commences September 3rd, 1923, at 9.30 o'clock.

Three year DIPLOMA COURSES in—
MECHANICAL ENGINEERING.
ELECTRICAL ENGINEERING.
MOTOR CAR ENGINEERING.

Practice in the Laboratories, Drawing Office, Workshop and Field.

Fee 21 Guineas per annum.

The EVENING DEPARTMENT re-opens on September 24th, 1923. Students enrolled from September 14th, 1923.

The Day and Evening Courses are recognised for the Diplomas and Certificates issued by the Institution of Mechanical Engineers in conjunction with the Board of Education.

Full prospectus free on application to the DIRECTOR OF EDUCATION. B 381

City of Cardiff Education Committee.

THE TECHNICAL COLLEGE.
Principal: Charles Coles, B.Sc. (Lond.).

DEPARTMENT OF ENGINEERING.
Head of Department: A. W. Loveridge, B.Sc. (Eng.), A.R.C.Sc.

SESSION 1923-24.
(Commencing on Tuesday, 2nd October, 1923).

The following Courses have been arranged for Engineering students:—

A Three-Years' Course in Mechanical and Marine Engineering jointly with the University College of South Wales and Monmouthshire.

A Two-Years' Course for apprentices and others with facilities for practical experience in the Summer Term.

These courses are suitable for students preparing for degrees in Engineering or for the Examinations of the Engineering Societies.

Special Courses are also arranged for Marine Engineers preparing for the Examinations of the Board of Trade.

OPEN SCHOLARSHIPS, covering tuition fees and maintenance grants of £40 per annum for three years, are offered for competition annually and candidates for entry to the above department are eligible to compete.

For further particulars of Full-time and Part-time Courses, Entrance Examination, Scholarships, Fees, etc., apply to the PRINCIPAL. Application forms for Entrance Scholarship Examination, duly filled up, must be received before September 17th.

JOHN J. JACKSON, Director of Education, City Hall, Cardiff. B 386

University of Manchester.

PHYSICS DEPARTMENT.

Full particulars of the Lectures and Laboratory Courses in Physics, preparing for both the Ordinary and the Honours Degrees, will be forwarded on application to the INTERNAL REGISTRAR.

Professor Bragg will meet intending Students on the 2nd and 3rd October, 10 to 1 and 2 to 4 p.m. B 344

University of Manchester.

FACULTY OF SCIENCE.

DEPARTMENTS OF CIVIL, MECHANICAL AND ELECTRICAL ENGINEERING.

COMPLETE COURSES OF STUDY, extending over three years, lead to the University Degree in Civil, Mechanical and Electrical Engineering. Students who have shown exceptional ability during the first year are admitted to the Honours Courses.

The Session commences on the 4th October.

A Prospectus giving full particulars may be obtained on application to the Internal Registrar.

HEADS OF DEPARTMENTS.
Professor A. H. GIBSON, D.Sc., M.Inst.C.E., M.I. Mech.E. (Engineering).
Professor ROBERT BEATTIE, D.Sc., M.I.E.E. (Electrical Engineering).
Professor SYDNEY CHAPMAN, M.A., D.Sc., F.R.S. (Mathematics).
Professor ARTHUR LAPWORTH, D.Sc., LL.D., F.R.S. (Chemistry).
Professor W. L. BRAGG, M.A., F.R.S., Nobel Laureate (Physics).
Professor F. C. THOMPSON, B.Sc., D.Met. (Metallurgy).
Professor O. T. JONES, M.A., D.Sc. (Geology).
Students specialising in Water Supply and Irrigation, work under the direction of Associate Professor SANDEMAN, M.Sc., M.Inst.C.E. B 343

Finsbury Technical College,

Leonard Street, City Road, E.C. 2.

CIVIL AND MECHANICAL ENGINEERING.
Professor H. P. Philpot, A.M.Inst.C.E.
ELECTRICAL ENGINEERING.
Professor W. H. Eccles, D.Sc., F.R.S.
CHEMISTRY.
Professor A. G. Hale, F.I.C.

The College provides practical scientific training for students who desire to become Civil, Mechanical or Electrical Engineers or Chemists.

Candidates are required to pass an Entrance Examination in Mathematics and English, but the Matriculation Certificate of any British University, and certain other qualifications, are accepted in lieu of it. The next Entrance Examination will be held on Tuesday, 18th September. Applications for admission should be forwarded to the College on forms to be obtained from the REGISTRAR. The Programme of the College may be had on application. B 47

Heriot-Watt College Edinburgh.

Principal—A. P. Laurie, M.A., D.Sc.

ENGINEERING.

Complete Diploma Courses in MECHANICAL ENGINEERING, ELECTRICAL ENGINEERING, and MINING ENGINEERING (COAL, METALLIFEROUS, OIL).

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Courses for Diploma and Associateship of College in Organic and Mineral Chemistry, Metallurgy and Assaying, Oil Technology, Industrial Bacteriology, and for the Brewers' Certificate and Brewers' and Analysts' Diploma, also for the Associateship of the Institute of Chemistry (A.I.C.), and for the B.Sc. Degree of Edinburgh University in Technical Chemistry and the B.Sc. Degree of London (Pass and Honours).

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Laboratories equipped for Research Students.

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Courses for Students preparing for the Professional Examinations of the Pharmaceutical Society of Great Britain ("Qualifying" and "Major" Examinations).

Courses in BUILDING CONSTRUCTION for Builders' Clerks and Surveyors, and in PRINTING, for those engaged in Printing and the Allied Trades.

Entrance Bursary of £25. Schedules on application.

Classes open on 9th October.
Entrance and Bursary Examination commences on 25th September.

Prospectus on application to Principal at the College.
PETER MACNAUGHTON, S.S.C. Clerk.

Heriot Trust Offices,
Edinburgh, August, 1923. B 382

Correspondence Courses for Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, Trafford Chambers, 58, South John Street, Liverpool. 1295

Engineering Salesmanship and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1587

Civil Service Commission.

FORTHCOMING EXAMINATION.

PROBATIONARY ASSISTANT ENGINEER in the Engineer-in-Chief's Department of the General Post Office (20-25, with extension in certain cases), 27th September.

The date specified is the latest on which applications can be received. They must be made on forms to be obtained, with particulars, from THE SECRETARY, Civil Service Commission, Burlington Gardens, London, W. 1. B 388

TENDERS.

THE MINISTRY OF PUBLIC WORKS, EGYPT, invite

Tenders for Three 40 ft. Steam Launches.

Tenders must be addressed to The Inspector General of Irrigation, Khartoum, Sudan, and will be received until NOON, 1st October, 1923.

Forms and Conditions of Tender can be obtained at the Offices of THE INSPECTING ENGINEER, Egyptian & Sudan Governments, Queen Anne's Chambers, Westminster, S.W. 1. B 385

WAR DEPARTMENT.

Tenders are Required

for the PURCHASE and REMOVAL of the undermentioned SURPLUS MACHINERY.

Five ton STATIONARY STEAM CRANE (by Stothert & Pitt, Bath), slewing with movable jib. Max. height of lift, 20 ft. Max. radius 18 ft. Tested January, 1922, to 10 per cent. over load.

BOILER, 3 ft. 6 in. by 7 ft. 7 in., working pressure 80 lbs. per square in. Passed by M.S.U.A. this year, no defects noticed.

Now lying at Elphinstone Barracks, Plymouth, can be seen any day on application to the C.R.E.S.W.A., C.R.E. Office, Mount Wise, Devonport.

Forms of Tender, conditions of Contract, permits to view and all other information can be obtained from the undersigned up to the 31st August, 1923.

A. DENNY, Captain and Qr.-Mr., R.E.
O. 1/c R.E. Stores, Plymouth District, for C.R.E., South Western Area.
R.E. Stores Office,
Cumberland Block,
Devonport. B 374

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for:—

87 TONS WROUGHT IRON, GRADE A.

Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C. 2, on or after Monday 20th August, 1923.

A fee of £1 1s. will be charged for the Specification, which is NOT returnable.

Tenders must be submitted not later than NOON on Monday, 3rd September, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. C. VOLKERS,
Secretary. B 394

AGENT-GENERAL FOR VICTORIA (AUSTRALIA).
Melbourne Place, Strand,
London, W.C. 2.

CONSTRUCTION OF BRIDGE FOR COUNTRY ROADS BOARD, VICTORIA.

Tenders, Addressed to

The AGENT-GENERAL, and endorsed "Tender for Barwon River Bridge," will be received at this Office until TWELVE o'clock Noon on Wednesday, 24th October next, for the ERECTION of a BRIDGE over the Barwon River at Geelong, Victoria, consisting of 417 lin. ft. of deck plate girder bridge, with concrete deck, 1200 lin. ft. of approaches and 16,000 cubic yards of river excavation.

Plans and Specifications may be inspected at this Office. The lowest or any Tender not necessarily accepted. Preliminary deposit £500. B 395

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following STORES, namely:—

		Fee for Specification.
No. 1.	Platelayers' Tools	5/-
No. 2.	Dressed Wagon Covers	£1
No. 3.	Pressed Steel Sleepers	£1
No. 4.	Bolts, Nuts and Rivets	10/-
No. 5.	Brass and Iron or Steel Screws	7/6
No. 6.	Steel Drawbars for Wagons ...	2/6
No. 7.	Ferro-Prussiate Paper	2/6
No. 8.	Metals, etc.	7/6
No. 9.	Miscellaneous Articles and Materials...	7/6
No. 10.	Four-Wheel Goods Brake Body Skeletons with Rolled Steel Disc Wheels and Axles, Axle-boxes, Laminated Springs, Buffers and Drawgear with Helical Springs, Screw Couplings, Vacuum Brakes (except Cylinders) and Hand Brakes (5ft. 6in. gauge)...	£1

Specifications and Forms of Tender may be obtained at this Office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Platelayers' Tools," or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 4th September, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.
Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 22nd August, 1923. B 426

STROMNESS HARBOUR, ORKNEY.

ERECTION OF PIER.

The Harbour Commissioners of Stromness invite

Offers for the Erection of a NEW PIER in Reinforced Concrete.

Schedule, Conditions of Contract and Drawings may be had from the Commissioners' Engineer, Mr. Jas. A. Liddle, Pentland Engineering Works, Gorgie, Edinburgh, on and after 24th August, 1923, on deposit of One Guinea, which will be refunded to all *bona fide* offerers. Sealed offers marked "Tender for New Pier" to be lodged with the undersigned not later than 12th September, 1923.

The lowest or any Offer may not be accepted.

ROBERT S. ROBERTSON, B 400
Clerk to Harbour Commissioners of Stromness.

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Wednesday, 12th September,

Tenders for the Supply of:—

BRAKE BEAMS, SPRING WASHERS AND AXLEGUARDS.

Tenders must be made on Forms, copies of which, with Specification, can be obtained at these Offices on payment of 10s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.
Offices: 91, Petty France,
Westminster, S.W. 1.
20th August, 1923. B 409

CORPORATION OF DUBLIN.

The CORPORATION OF DUBLIN are prepared to receive

Tenders for One Pumping UNIT,

consisting of an OIL ENGINE and CENTRIFUGAL PUMP, having a 21-in. delivery pipe, to raise sewage against a maximum head of 18 ft.

Particulars and Form of Tender may be obtained on and after Tuesday, 28th August, 1923, at the Office of the City Engineer, 28, Castle Street, Dublin, and of Mr. J. S. Alford, M.Inst.C.E., 11, Victoria Street, Westminster, London, S.W. 1, upon payment of Two Guineas (cheque only). The deposit will be refunded to those sending in *bona fide* Tenders.

Tenders (marked on the envelope "Tender for Storm Pump") are to be addressed to the Chairman of the Streets Committee, 26, Castle Street, Dublin, and must be forwarded so as to reach him not later than Noon on TUESDAY, 25th of SEPTEMBER, 1923.

The Corporation do not bind themselves to accept the lowest or any Tender.

JOHN J. MURPHY,
Town Clerk.
Dublin, 21st August, 1923. B 398

METROPOLITAN WATER BOARD.

COVERED SERVICE RESERVOIR AT CHELSFIELD, KENT.

The Metropolitan Water Board invite

Tenders for the Construction

of a COVERED SERVICE RESERVOIR of a capacity of about three-quarters of a million gallons, at Chelsfield, in the Rural District of Sevenoaks, in the County of Kent.

Drawings, Conditions of Contract and Specification, may be inspected without payment of a fee, at the Offices of the Board, Chief Engineer's Department (Room 201), on and after 20th August, 1923.

Forms of Tender, Conditions of Contract, Specification, Bills of Quantities and Schedules of Prices, together with Drawings and a spare copy of the Bills of Quantities may be obtained on and after 27th August, 1923, from Mr. Henry E. Stilgoe, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £10, which sum must be deposited with the Accountant to the Board, and will be returned on receipt of a *bona fide* Tender, accompanied by all the above-named documents and drawings (with the exception of the spare copy of the Bills of Quantities, which may be retained by the Tenderer).

Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays Ten a.m. and Twelve noon). Cheques must be made payable to the "Metropolitan Water Board" and not to individuals.

Tenders enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, 173, Rosebery Avenue, London, E.C. 1," and endorsed "Tender for covered service reservoir at Chelsfield," must be delivered at the Offices of the Board not later than Ten a.m., Monday, 17th September, 1923.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.
Offices of the Board,
New River Head,
173, Rosebery Avenue, E.C. 1.
7th August, 1924. B 354

APPOINTMENTS OPEN.

FINSBURY TECHNICAL COLLEGE.

Applications are Invited for

the Undermentioned Posts in the Department of Civil and Mechanical Engineering and Applied Mathematics:—

(1). LECTURER IN MATHEMATICS AND APPLIED MECHANICS.—Applicants should be of Graduate Rank and should have special knowledge of the requirements of engineering students.

(2). ASSISTANT INSTRUCTOR IN MECHANICAL DRAWING. — Practical Experience in Engineering Workshops and Drawing Office is essential.

The duties of the posts will commence at the beginning of October next.

The salaries attached to the posts will be in accordance with the London County Council scale of salaries for Teachers in Technical Institutions.

Applications, with copies of testimonials, particulars of teaching and professional experience, should be addressed to Professor H. P. PHILPOT, Finsbury Technical College, Leonard Street, City Road, and should be received not later than 5th September, 1923. B 418

SÖDERTÄLJE CANAL LOCK.

ALTHOUGH not perhaps so favourably adapted to canal transport as some countries Sweden possesses some important inland waterways. The numerous lakes form serviceable links in these systems, of which the two most important are the Trollhätte and the Gotha Canals. Both these connect with Lake Vänern, one running south to the Kattegat, and the other east to the Baltic coast line, thus putting numerous inland ports in direct communication with the seas, and further providing a valuable short cut through sheltered water to Baltic ports in the Stockholm region.

Another important waterway is the Södertälje Canal, which, in accordance with its development policy, the Government is now reconstructing. The idea of a canal at Södertälje dates back to the fifteenth century, which appears to have been fruitful in canal projects in Sweden, even if nothing very important was accomplished for some time afterwards. The beginning of the nineteenth century witnessed the completion of several of the major projects, the flight of locks at the Trollhätte Falls having been completed in 1800, the Gotha Canal being finished in 1832 and the Södertälje Canal in 1819. Smaller waterways were also reconstructed at this time.

The Södertälje Canal with which we are now particularly concerned, connects Lake Mälaren with the sea, by cutting through a narrow neck of land which entails a canal only 2·8 km. long. This neck is on the southern side of the lake. At the eastern extremity of the lake stands the city of Stockholm, with its intricate system of land-locked water. The normal approach to the city is from the Baltic to the east, but the passage is long and tortuous. The canal at Södertälje not only gives a number of ports on Lake Mälaren direct access to the sea in a southerly direction, but also provides, so to speak, a back way to Stockholm for the smaller type of sea-going vessel. In course of time this route to Stockholm may develop into one of considerable importance. At present we understand the use of the Stockholm harbours is handicapped by the existence of a single lock across which a large part of the city's road traffic has to pass. The movement of both shipping and road traffic is thus interfered with. The Södertälje route makes it possible to reach a large part of the port and to avoid this congested lock, while another important enterprise, now being carried out by the city itself, will ultimately make the whole port readily accessible to boats coming by the Södertälje route, and these would be able to continue their course on eastwards into the Baltic. We refer now to the Hammarby Canal and Harbour, which the city of Stockholm is developing on its southern side. This undertaking will add considerably to the accommodation of the port, and it will communicate by means of a lock with the Ärsta-viken, an arm of the Lake Mälaren. This lock is being built similar to that on the Södertälje Canal, so that vessels using the latter will be able to pass through this canal with equal facility. The accompanying map, Fig. 1, shows the situation of Södertälje, Stockholm and the Hammarby Canal in relation to Lake Mälaren. The routes on the lake are also indicated and deep channels are being made to the various ports, where also steps are being taken to provide accommodation for the anticipated traffic. Some of these ports, such as Vesterås, are interested in the shipment in bulk of iron ore and wood, and in importing coal, and it is expected that when the present improvements are completed direct traffic with foreign ports will develop to the advantage of these inland points which now suffer from enforced transhipment.

Fig. 1.

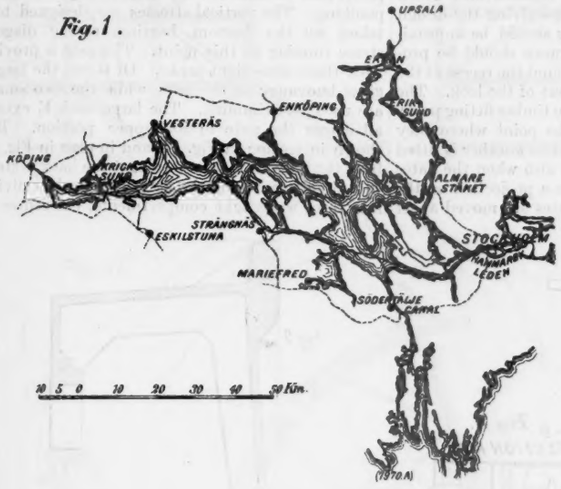


Fig. 2.

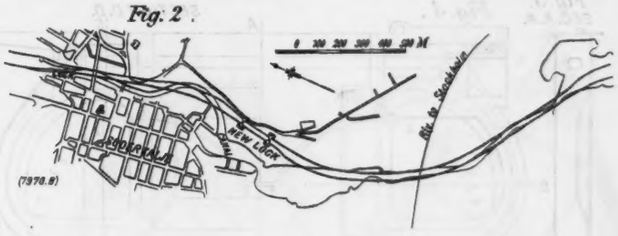
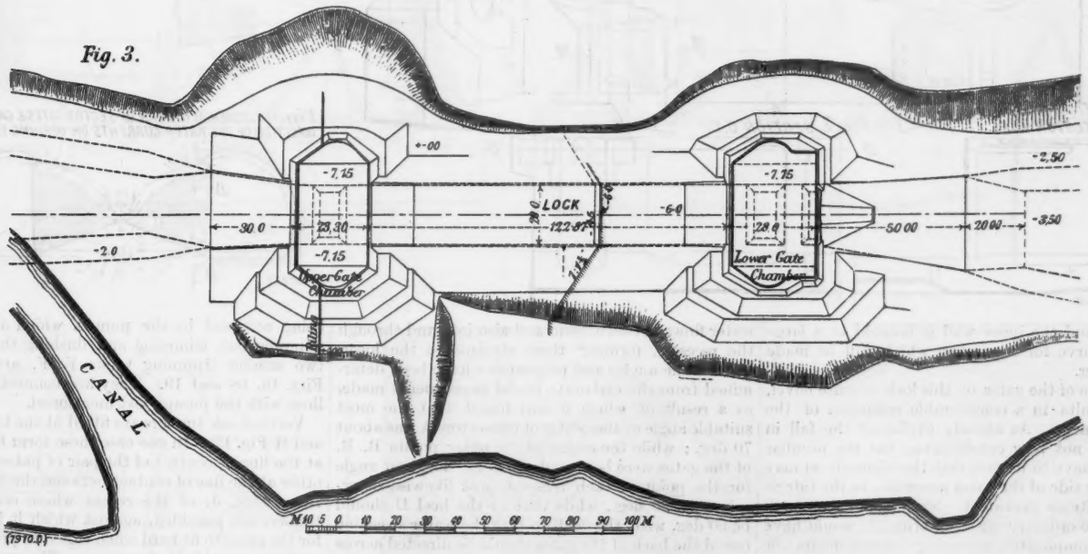


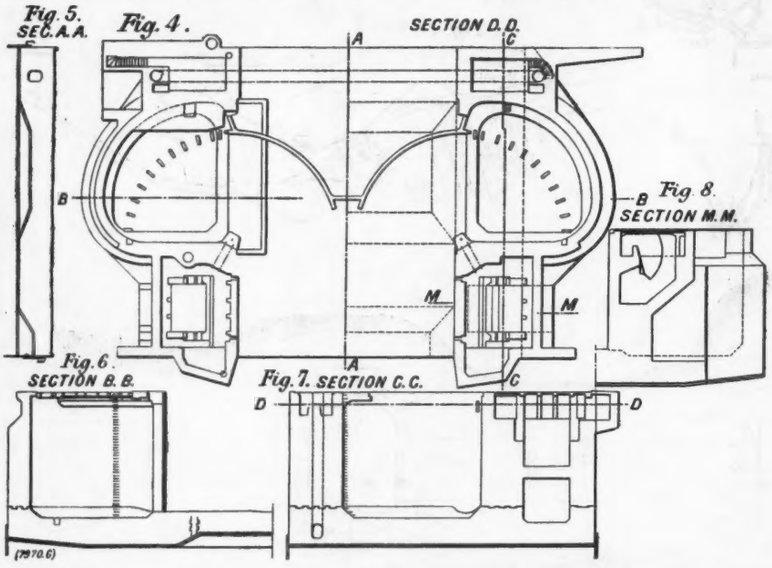
Fig. 3.

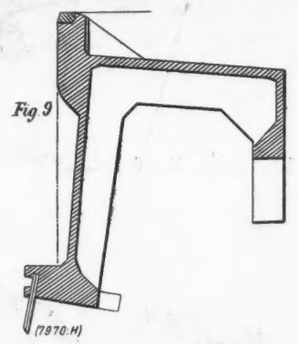


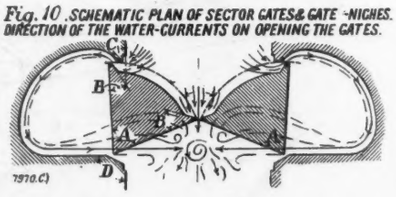
Both the Södertälje and the Hammarby Canals are to be made capable of taking vessels drawing 5·5 m. (18 ft.) and vessels carrying 3,700 tons of cargo will be able to pass through them. The work of dredging the Södertälje Canal will be completed next year, and the channels in Lake Mälaren are expected to be finished in 1925. The Hammarby Canal will not be finished till 1926. By the courtesy of the Royal Board of Waterfalls, Stockholm, we are now able to give some particulars of the work on the Södertälje Canal.

A view on the old Södertälje Canal is given in Fig. 12, page 240, and contrasts greatly with that in Fig. 11, which illustrates the new lock which has recently commenced working, though, since the old canal section has not been enlarged throughout, the size of vessel is still restricted to the small boats which have been able to use the canal in the past. A plan of the new alignment is given in Fig. 2, from which it will be seen that the new course taken is much improved and a number of troublesome bends have been eliminated. The canal is fitted with one lock only, which has, however, to meet somewhat unusual conditions. Although the difference of water level at the lock is normally not greater than 1 m. 70 (5 ft. 7 in.) it happens that at certain periods the excess of head is in the "up-stream" direction. Usually the level of Lake Mälaren is above that of the Baltic. For about five weeks in the year, however, the Baltic level may be as much as 40 cm. (1 ft. 4 in.) above that of the lake. The difficulty of contending in a simple and effective manner with these conditions have been met in a very interesting manner. The lock has been built with an eye to the future. It will allow the passage of vessels drawing 6·5 m. to 7 m. (21 ft. 4 in. to 23 ft.), has a usable length of 135 m. (443 ft.), and a clear width at the gates of 20 m. (65 ft. 7½ in.), the actual depth on the sill being 7·50 m. (24 ft. 7 in.) at low water. These dimensions would enable vessels carrying 7,000 tons to 8,000 tons of cargo to negotiate the lock, though at first no provision for anything like this will be made in the channel. A plan of the excavation at the lock site is given in Fig. 3, and shows the position of the upper and lower gate chambers, which are independent structures of

reinforced concrete, and of which a good idea may be gathered from the small scale drawings, Figs. 4 to 8, showing the concrete structure for the lower pair of gates. The canal is finished to sloping sides, and floating timber guides are arranged at either end of the lock. The lock chamber is provided with one sloping side, which, with the bottom, is pitched with stone blocks. The other side is built as a quay wall in reinforced concrete, supported on piling. A section of this wall is given in Fig. 9. The upper portion is faced with stone. A line of sheet piling is carried in front of the upper side of the upper lock chamber, and cut off wings of piling are carried well out on either side. At the lower chamber sheet piling surrounds the whole of the outer edge of the concrete work, but it is not carried out to the sides. The most noticeable feature of the concrete lock structures is the type of gate recess adopted. These recesses are much deeper than is required with the ordinary mitreing leaf type of gate, and this is necessitated by the new design of gate which has been introduced for the first time at this lock. The recesses are, moreover, made a good deal deeper than is actually required to house the gates, and the inner wall is finished to a large sweeping curve for a purpose which will be made evident later.







The design of the gates of this lock is quite novel, and it results in a considerable reduction of the lock machinery. As already explained the fall in this case is not very considerable, but the peculiar conditions have to be met that the higher level may be on either side of the gates according to the tide or flood conditions prevalent. Such conditions with gates on the ordinary mitreing principle would have involved complicated reversing arrangements or double pairs of gates. Both these are costly expedients, and an altogether different solution was arrived at. As a result of a long series of model experiments sector gates were designed capable of taking the pressure resulting from a head on either side. The gates themselves are shown in the drawings, Figs. 13 to 19, page 227, while the view reproduced in Fig. 22 shows one gate very clearly in position in the lock, the second of the pair being partly seen on the extreme right of this view.

The main feature of the design lies in the fact that the plating receiving the pressure of the water held up, is struck to an arc of a circle in plan, so that the resultant force passes through the vertical axis on which the gate turns. This is approximately the effect whichever side the excess of head happens to be. The gates have further advantages. The force required to open them is small, even in running water, while opening is a much more expeditious operation than with mitre gates owing to the resistance to turning of the gate being much lower than the force required to swing a hinged leaf. Another considerable advantage is that the gates themselves operate as sluices so that the mechanical and structural complications of the usual valves and filling conduits are obviated. Thus, although the gates are rather more costly than plain mitre gates, involving as they do rather more steel work, the whole equipment works out at much less expense, with much enhanced simplicity as regards maintenance, and also control.

Before dealing with the gate structures reference to the diagram, Fig. 10, will help to make the principle on which they work clear, and will elucidate the drawings reproduced. This diagram shows in plan a pair of gates with the recesses into which they swing. The main ideas underlying the design are that, as stated, the plating should be approximately circular, and that clearance should be provided so that water can sweep round the recess at the back of each gate and into or out of the lock. The gates are each furnished with two timber fitting posts. One is arranged on each at the point where they come in contact when closed, while another is fitted at the opposite end and butts, also when the gates are closed, up against a post on a projection on the recess wall. As soon as the gates are moved apart water flows between them and also into and through the recesses, forming three streams to the lower level. The angles and proportions have been determined from the elaborate model experiments made, as a result of which it was found that the most suitable angle at the centre of the sectors A was about 70 deg.; while the angles at the outer points B, B, of the gates were best made 20 deg. The best angle for the point of each recess C was likewise determined as 20 deg., while that at the heel D should be 90 deg. with the wall so that the water sweeping round the back of the gates should be directed across the dock to meet at the centre and mix there with the water flowing in between the gates. With the above proportions it is found that about one-third of the water passes between the opening gates, two-thirds being diverted through the recesses. The converging of the streams and the lateral direction of two-thirds of the volume of water in opposite directions across the lock is found to obviate all danger from turbulence, so that the control of vessels in the lock is quite easy, although water is only admitted at one end. Of course, in this case the difference in level is never very great, but the time occupied in filling is further improved with these gates for this very reason, while the operation is so satisfactory that the engineers consider that there is no reason why the same principle should not be adopted for greater differences of level.

The gates, as stated, are illustrated in Figs. 13 to 19. Each consists of a main top and bottom and side frames of rolled steel members, with three horizontal intermediate frames. A plan of the top frame is given in Fig. 17, of the bottom frame in Fig. 19, while the intermediate frames are illustrated by Fig. 18. Fig. 13 gives a side elevation; Fig. 14 a part section through the axis carried from the plating to a line just beyond the central stanchion. Fig. 15 shows in elevation the cross bracing nearest the pintle, while Fig. 16 gives the plating in elevation. The top and bottom horizontal frames together with the two side frames of which the elevation is given in Fig. 13, constitute the main structure. This framing is built up of channels and angles. Vertical channel stiffeners extend from the top to the bottom of the gate behind the plating, which has a thickness of 9 mm. Outside and attached to the plating protection is afforded by heavy vertical timber planking, The vertical stresses are designed to be taken by the bottom bearing, strong diagonal struts running to this point. The gate is provided with three watertight tanks. Of these, the largest, gives buoyancy to the gate, while the two smaller are used for trimming. The large tank E extends all across the gate in its upper portion. It is shown in section in Fig. 14, and in plan in Fig. 18; from the latter it will be seen that the back is struck to a circular arc from the axis. This tank is divided into three watertight compartments, the centre one being occupied by the pumps, which are used for pumping out, trimming and flushing the sill. The two smaller trimming tanks F, F, are shown in Figs. 16, 18 and 19. They are connected by pipe lines with the pumps just mentioned.

Vertical oak timbers are fitted at the two points G and H Fig. 17. In one case these form fitting strips at the line of contact of the pair of gates, and in the other at the line of contact between the gate and the front edge, J, of the recess where corresponding timbers are provided, against which it is necessary for the gates to fit hard when closed to prevent water working round into the recess. The projections on the gate are provided in order to direct a good proportion of the flow into the recesses, and keep it well out to the walls so that it sweeps round and emerges properly from behind the gates in the intended direction at right angles to the axis of the lock. Further, a circular oak fitting-timber is provided all along the lower edge of the plated front of the gate at K, Fig. 14. This is in contact with a cast-iron sill rail laid in the floor of the lock chamber, and having a slope of 1 in 150 towards the centre of the lock. The weight of the gates thus tends to bring them together.

The bearings of the gate are indicated in Figs. 20 and 21. Both are spherical. The pintle, Fig. 21, consists of a ball of cast steel of 0·8 per cent. carbon and 1·5 per cent. chromium. The bushings and pad are of hard phosphor bronze. The pintle is fixed in the lock masonry and the cup is bolted solidly to the main frame members of the gate. The upper bearing is, however, adjustable both as regards the part fixed to the gate and also that anchored to the lock wall. The adjustment on the

GATES FOR THE SÖDERTÄLJE CANAL LOCK.

Fig. 13. ELEVATION A.A.

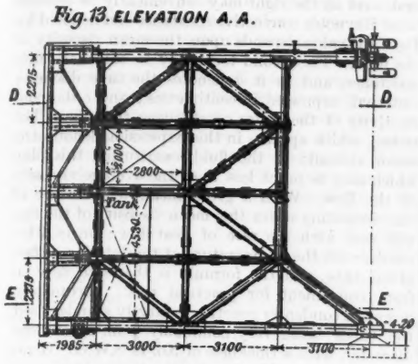


Fig. 14. SECTION B.B.

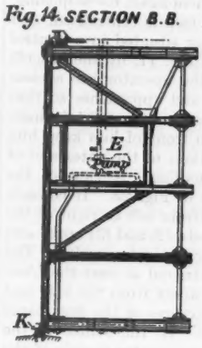


Fig. 15. SECTION C.C.

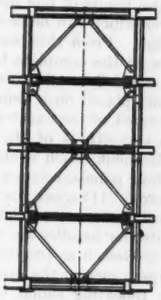


Fig. 16. ELEVATION D.D.

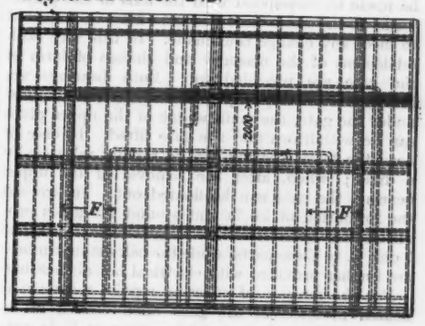


Fig. 17.

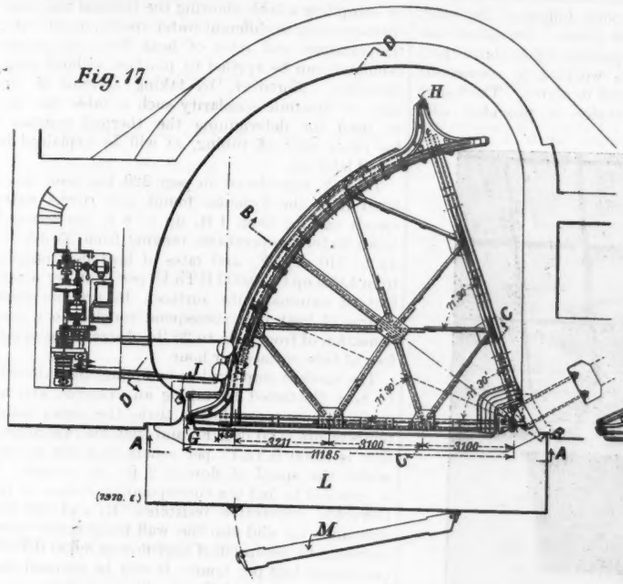


Fig. 18. SECTION D.D.

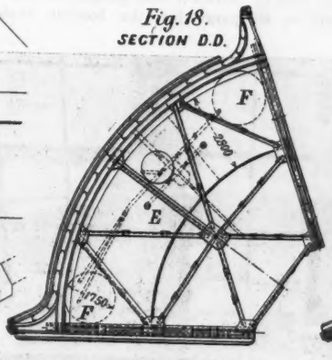
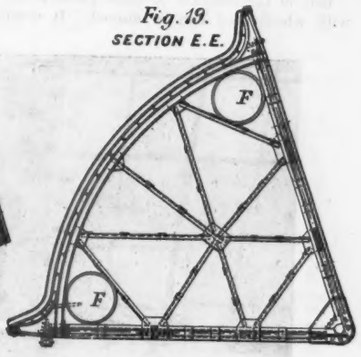


Fig. 19. SECTION E.E.



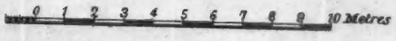


Fig. 20.

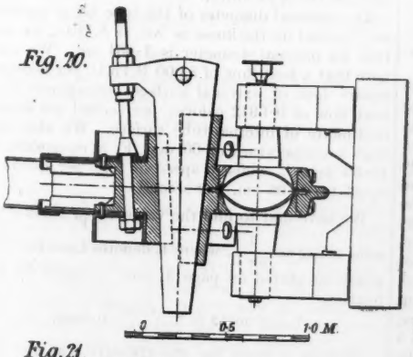
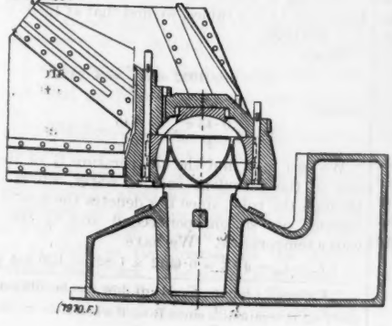


Fig. 21.



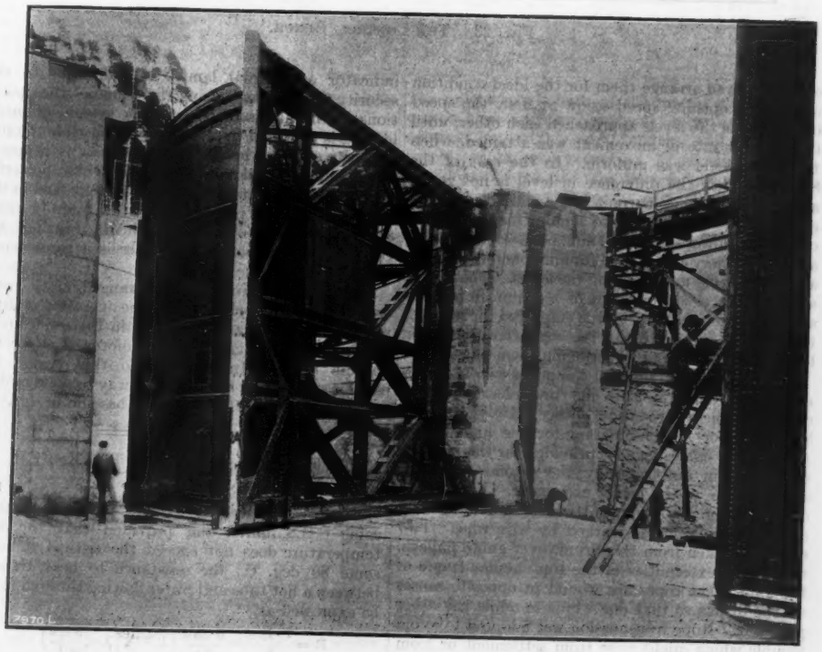


FIG. 22.

gate itself is made by the large wedge shown, locked in position by the screw and pair of nuts. Other wedges are provided on the wall fixture so that this pivot is capable of adjustment and may always be made to correspond with the axis of the pintle, while at the same time the gate may be adjusted to meet any change thus made. In this way both settlement of the masonry and change of form of the gate are provided for. Both bearings are lubricated. If any object should become jammed under the gate, the main wedge of the upper pivot can be withdrawn and the gate lifted. In case of need the lower bearing can be rapidly released by a diver; when, after the removal of the upper bearing, the gate can be floated out. To prevent the formation of ice in and around the gates provision has been made to drain water at about 7 deg. C. to these parts, while the oak fitting-timbers are further provided with electrical hot air heating.

For the purpose of effecting repairs a caisson is floated in front of the gate when housed in its recess. This is indicated in position at L, in outline in Fig. 17. The recess can then be pumped out. A reserve mitre gate M is fitted to the back of each caisson so that the lock can still be operated under these conditions.

One of the features of these gates is the facility with which they can be moved. It would be an easy matter to arrange them for the ideal condition of variable opening speed—slow at first, the speed increasing as the levels approached each other, until the greatest rate of movement was attained, when the water level was uniform. In the case of the Södertälje lock the difference in level is not great, and as alternating current was available it was considered to be sufficient to arrange for two speeds only. The lower speed is 10 mm. per second (0·4 in.) at the periphery and is used for filling and emptying, and for starting and stopping the gates. The higher speed produces a movement of 150 mm. (6 in.) per second at the periphery and is employed for running the gates rapidly into the recesses after the water level is equalised, and for bringing them out again.

The arrangement adopted comprises two 15-b.h.p. motors working on 220-volt three-phase 50-cycle current. These are used either singly for the low speed, or in combination for the high speed. A system of float gauges is provided for the purpose of cutting in automatically the second motor as soon as the water levels are equal. The motor drive (see Fig. 17) is transmitted to a double winding drum, the gates being worked by wire rope. Two ropes are taken from this drum, over guide pulleys, to the two extremities of the top circular frame of the gate. The ropes are wound in opposite senses on the drums so that one winds in while the other pays out. Rope transmission was adopted to avoid trouble which might arise from settlement or from vibration of the gate. The ropes give a certain amount of flexibility to the drive, while some elasticity is also provided at the point of attachment of the ropes to the gates. The tension on this gear when the gates come into their final closed position assists in starting to move them again for reopening.

The whole control of the lock is centralised, and in the hands of one operator situated in a control tower which can be seen in Fig. 11, by the bascule bridge. From this tower the operator has a clear view of the complete lock and approaches so that he can follow all movements, while tell-tale indicators placed on a bench in front of him keep him informed of the exact positions of the gates and of the correctness of the signalling. A view of the instrument bench is shown in Fig. 23. It consists of four panels, relating to (from left to right of the figure): (1) Signals for vessels, (2) and (3) upper and lower gates, (4) highway bascule bridge. The controller handles are all situated as near the front of the bench as possible. Apart from the volt and ampere meters the other fixtures in the first panel are repeating signal lights. In the centre of the second and third panels are indicator models of the gates and recesses, the models following the exact movement of the full-sized gates. On either side of these are signal lamp repeaters, while above them are water level indicators working in connection with the float gauges referred to above. The fourth panel for the bascule bridge is provided with indicator and signal lamps. In addition to the security ensured by placing the whole of the operations in the hands of one man, a system of interlocking is provided by which it is impossible to open one pair of gates before the other pair is properly closed. The signal lamps are sufficiently powerful to be used in bright sunlight. A switchboard in the control tower is provided for the main current supply, all motors, and for lighting, heating, &c. On the ground floor of the tower is a transformer room.

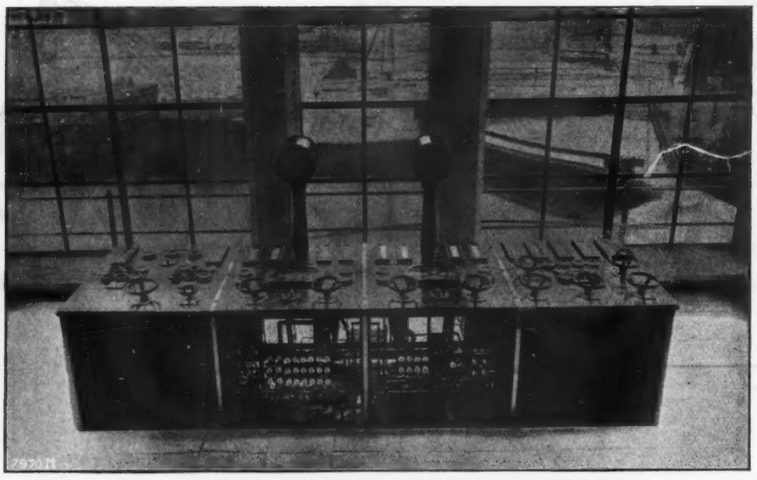


Fig. 23. The Control Bench.

Rectangular chambers are arranged in the concrete work at the lock gates, for the operating motors, while the larger chambers shown in Figs. 4, 7 and 8 are for the tail, kentledge and motor gear for the bascule bridge. In addition to this bridge the canal is spanned by a second highway bascule bridge, and also by a high level railway bascule bridge.

THE LAWS OF HEAT TRANSFER.

(*Concluded from page* 132.)

From the preceding articles it appears that, using C.G.S. units, and provided that the wall temperature does not exceed the critical value of some 80 deg. C., the resistance to heat transfer between a hot tube and water flowing through it can be expressed as

$$R = \frac{0{\cdot}45\,v}{F} + \frac{0{\cdot}55\,d}{2\,c}\left(1 - \sqrt[4]{1 - \frac{8\,\bar{\mu}\,v}{d\,F}}\right)$$

Where R denotes the total thermal resistance in C.G.S. units, v the mean velocity of flow in centimetres per second, and F the frictional resistance in dynes per square centimetre of tube surface. The first term on the right may conveniently be referred to as Reynolds convective resistance and denoted by R_r. Its value depends upon the mean viscosity of the fluid. The second term may be called the film resistance, and in it d denotes the tube diameter (internal) expressed in centimetres; and c the conductivity of the water constituting this film. The term $\bar{\mu}$ which appears in this expression denotes the mean viscosity of the fluid constituting this film, which may be much less than the average viscosity of the flow. With a given mean temperature of the circulating water this mean viscosity of the film will vary with the rate of heat flow; or, in other words, with the temperature of the interior surface of the tube, and the formula is therefore very far from convenient for practical use. Fortunately, however, condenser practice is largely standardised, the tubes being very commonly $\frac{3}{4}$ in. in external diameter, with a thickness of No. 18 S.W.G. Hence by compiling a table showing the thermal resistance corresponding to different water speeds, mean water temperatures and rates of heat flow, the results tabulated can be applied to practice without much difficulty. Moreover, by taking account of the laws of dynamic similarity such a table can also be used for determining the thermal resistance for other sizes of tubing, as will be explained in detail later on.

Table V, reproduced on page 229, has been calculated from the formulas found, and covers water speeds ranging from 1 ft. up to 8 ft. per second,* mean water temperatures ranging from 35 deg. F. up to 110 deg. F., and rates of heat flow ranging from 4,000 up to 20,000 B.Th.U. per hour per square foot of external tube surface. In practice these figures of heat flow correspond roughly to a condensation of from 4 lb. to 20 lb. of steam per square foot of tube surface per hour.

The method employed in compiling the table will be best illustrated by taking an example, and we shall assume accordingly that the mean water temperature is 60 deg. F., and that the rate of heat flow is 8,000 B.Th.U. per square foot per second, whilst the speed of flow is 2 ft. per second. It is required to find the corresponding values of the Reynolds convective resistance R_r and the film resistance R_f, and also the wall temperature corresponding to the specified heat flow of 8,000 B.Th.U. per square foot per hour. It will be assumed that both the density and the specific heat of the water may be taken as unity.

The external diameter of the tube being specified as $\frac{3}{4}$ in. and its thickness as No. 18 S.W.G., we find that its internal diameter is 1·661 cm. We next note that a heat flow of 8,000 B.Th.U. per hour per square foot of external surface corresponds to a heat flow of 0·6912 calories per second per square centimetre of internal tube surface. We also note that a temperature of 60 deg. F. is equivalent to 15·56 deg. C., whilst a speed of 2 ft. per second is equal to 60·96 cm. per second.

We have first to find the value of $\frac{v}{F}$, which is the same thing as $\frac{1}{\rho\,v\,L}$, where L denotes Lees' function which, as stated on page 3, *ante*, is given by the relation

$$L = 0{\cdot}00763\left(\frac{\mu}{\rho\,v\,d}\right)^{0{\cdot}35} + 0{\cdot}0009.$$

Plotting a curve for the viscosity μ as given in Kaye and Laby's tables, we find that at 15·56 deg. C. $\mu = 0{\cdot}01126$.

Hence

$$L = 0{\cdot}004052 \text{ and } \frac{v}{F} = 4{\cdot}049$$

so that

$$R_r = \frac{0{\cdot}45\,v}{F} = \frac{0{\cdot}045}{\rho\,v\,L} = 1{\cdot}822.$$

We can now find the temperature t_e of the outside of the turbulent core of water, which passes through the tube, since if q denotes the heat flow in calories per sq. cm. per second and t_w the mean water temperature. We have

$$t_e - t_w = q\,R_r = 0{\cdot}6912 \times 1{\cdot}822 = 1{\cdot}26 \text{ deg. C.}$$

* Values for higher speeds of flow can be obtained by plotting R against $\frac{1}{v}$ since R = 0 when $v = \infty$.

Hence

$$t_e = 15{\cdot}56 + 1{\cdot}26 = 16{\cdot}82 \text{ deg. C.}$$

To obtain the corresponding temperature t_i of the inner surface of the tube it is necessary to make a guess in the first place, and subsequently to check it, so that the true value is found by continued approximation.

In the present case we shall assume provisionally that $t_i = 28{\cdot}30$ deg. C. This then is the temperature of the outer surface of the film which creeps in viscous flow along the inner surface of the tube, and we already know that the temperature t_e of the inner surface of this film is 16·82 deg. C. Hence at mid-thickness we may take the temperature as sensibly equal to 22·56 deg. C.

Then if the viscosity of the water at the temperature t_i is denoted by μ_i and its value at the inner surface of the film by μ_e whilst $\mu_{\frac{1}{2}}$ denotes the viscosity at mid thickness, we get by one of the usual rules for approximate integration the following value for the mean viscosity $\bar{\mu}$ of the water constituting the viscous film, viz.,

$$\bar{\mu} = \tfrac{1}{6}\mu_e + \tfrac{2}{3}\mu_{\frac{1}{2}} + \tfrac{1}{6}\mu_i$$

Reading the values of μ_e, $\mu_{\frac{1}{2}}$ and μ_i from curves of viscosity plotted against temperature, we get

$$\bar{\mu} = 0{\cdot}00949.$$

We already know the value of $\frac{v}{F}$, which, as found above, is 4·049. We thus get

$$\frac{8\bar{\mu}v}{dF} = 0{\cdot}18507$$

Whence from Barlow's tables we easily get the value of

$$\sqrt[4]{1 - 0{\cdot}18507} = 0{\cdot}95012$$

so that

$$1 - \sqrt[4]{1 - 0{\cdot}18507} = 0{\cdot}04988$$

Hence the value of the film resistance is

$$R_f = \frac{0{\cdot}55\,d}{2\,c}\left\{1 - \sqrt[4]{1 - \frac{8\bar{\mu}v}{dF}}\right\}$$

and $d = 1{\cdot}661$ cm., whilst c, the conductivity of water, may be taken as 0·0014 C.G.S. units.

Hence in this case

$$R_f = 326{\cdot}3 \times 0{\cdot}04988 = 16{\cdot}273.$$

This value, however, requires a small correction to provide for the fact that the film is curved and not flat. Hence we take the true value of R_f as

$$16{\cdot}273\left(1 + \frac{0{\cdot}04988}{2}\right) = 16{\cdot}68$$

We have already found $R_r = 1{\cdot}82$. Hence R, the total thermal resistance between wall and water is

$$R = 16{\cdot}68 + 1{\cdot}82 = 18{\cdot}50.$$

To check our provisional assumption we note that $t_i - t_w$ must be equal to q R. Whence

$$t_i - t_w = 12{\cdot}97 \text{ deg. C.}$$

so that

$$t_i = 15{\cdot}56 + 12{\cdot}79$$
$$= 28{\cdot}35 \text{ deg. C.}$$

which is sufficiently near to the assumed value to require no further correction. We thus see that under the conditions stated the temperature of the inner surface of the tube is 83·03 deg. F., the temperature difference between wall and water being therefore 23·03 deg. F. In this way the remainder of the values tabulated in Table V have been computed, and an interpolation of these figures will cover the whole of ordinary surface condenser practice.

For water speeds higher than 8 ft. per second we can find values of R by plotting the tabulated values against $\frac{1}{v}$, and noting that when $\frac{1}{v}$ is 0, R must also be zero so that the process is the safe one of interpolation.

As already stated the table can also be used for other diameters of tubing, but before explaining how this may be effected it will be of interest to use the values found for analysing certain very interesting observations on a surface condenser which were described by Mr. J. M. Newton in a paper contributed in 1912 to the Journal of the Junior Institution of Engineers. The writer is indebted to Mr. W. Chilton, of the Brush Electrical Engineering Company, Loughborough, for a blue print showing the details of the condenser and for other data supplementing Mr. Newton's figures.

When the plant in question was first put into operation the air leakage proved to be excessive, and the performance of the condenser unsatisfactory.

The condenser and exhaust branch were accordingly filled with water up to the level of the spindle glands, and this operation disclosed the existence of numerous pinholes in the condenser and connecting pipe. These were stopped and a new trial made. Comparative figures for the two tests are given below.

TABLE V.—THERMAL RESISTANCE WITH STANDARD CONDENSER TUBES. (¾-IN. EXTERNAL DIAMETER, No. 18, S.W.G.) UNDER VARIOUS CONDITIONS.

Heat flow per hour per sq. ft. of external surface, B.Th.U.	4,000	8,000	12,000	16,000	20,000	4,000	8,000	12,000	16,000	20,000
Temperature of circulating water, deg. F.	35	35	35	35	35	85	85	85	85	85
Speed of circulating water, ft. per sec.	1	1	1	1	1	1	1	1	1	1
Convective resistance R_r, C.G.S. units	2·67	2·67	2·67	2·67	2·67	3·30	3·30	3·30	3·30	3·30
Film resistance R_f, C.G.S. units	39·73	33·13	29·31	26·82	24·20	24·09	21·92	20·25	18·67	16·78
Total resistance R, C.G.S. units	42·40	35·80	31·98	28·49	26·87	27·39	25·22	23·55	21·97	17·08
Temperature of internal surface of tube, deg. F.	61·37	79·54	94·68	107·46	118·57	102·04	116·37	128·94	139·72	148·69
Speed of circulating water, ft. per sec.	2	2	2	2	2	2	2	2	2	2
Convective resistance R_r, C.G.S. units	1·63	1·63	1·63	1·63	1·63	1·99	1·99	1·99	1·99	1·99
Film resistance R_f, C.G.S. units	23·97	21·31	19·41	17·99	16·75	14·34	13·47	12·76	12·18	11·71
Total resistance R, C.G.S. units	25·60	22·94	21·04	19·62	18·38	16·33	15·46	14·75	14·17	13·70
Temperature of internal surface of tube, deg. F.	50·92	63·53	74·26	84·23	94·54	95·15	104·23	112·23	120·67	129·38
Speed of circulating water, ft. per sec.	5	5	5	5	5	5	5	5	5	5
Convective resistance R_r, C.G.S. units	0·83	0·83	0·83	0·83	0·83	1·005	1·005	1·005	1·005	1·005
Film resistance R_f, C.G.S. units	12·56	11·49	10·85	10·37	9·79	7·156	6·946	6·736	6·541	6·374
Total resistance R, C.G.S. units	13·39	12·32	11·68	11·20	10·62	8·161	7·951	7·741	7·546	7·379
Temperature of internal surface of tube, deg. F.	43·33	50·33	56·80	62·71	68·04	90·08	94·90	99·44	103·77	107·95
Speed of circulating water, ft. per second	8	8	8	8	8	8	8	8	8	8
Convective resistance R_r, C.G.S. units	0·59	0·59	0·59	0·59	0·588	0·702	0·702	0·702	0·702	0·702
Film resistance, R_f, C.G.S. units	8·12	7·56	7·10	6·73	6·434	4·987	4·878	4·767	4·665	4·583
Total resistance R, C.G.S. units	8·71	8·15	7·69	7·32	7·022	5·689	5·580	5·469	5·367	5·285
Temperature of internal surface of tube, deg. F.	40·42	45·14	49·35	53·20	56·84	88·54	91·94	95·20	98·36	101·44
Temperature of circulating water, deg. F.	60	60	60	60	60	110	110	110	110	110
Speed of circulating water, ft. per sec.	1	1	1	1	1	1	1	1	1	1
Convective resistance R_r, C.G.S. units	3·00	3·00	3·00	3·00	3·00	4·33	4·33	4·33	4·33	4·33
Film resistance R_f, C.G.S. units	30·23	26·58	24·01	22·16	20·65	19·72	18·21	16·95	15·93	15·14
Total resistance R, C.G.S. units	33·23	29·58	27·01	25·16	23·65	24·05	22·54	21·28	20·26	19·47
Temperature of internal surface of tube, deg. F.	80·67	96·80	110·41	122·87	133·56	124·96	138·04	149·72	160·42	170·55
Speed of circulating water, ft. per sec.	2	2	2	2	2	2	2	2	2	2
Convective resistance R_r, C.G.S. units	1·82	1·82	1·82	1·82	1·82	2·61	2·61	2·61	2·61	2·606
Film resistance R_f, C.G.S. units	18·15	16·68	15·55	14·65	13·88	11·72	11·18	10·67	10·21	9·835
Total resistance R, C.G.S. units	19·97	18·50	17·37	16·47	15·70	14·33	13·79	13·28	12·82	12·441
Temperature of internal surface of tube, deg. F.	72·42	83·03	92·42	101·44	110·87	118·91	127·16	134·79	141·93	148·69
Speed of circulating water, ft. per sec.	5	5	5	5	5	5	5	5	5	5
Convective resistance R_r, C.G.S. units	0·93	0·926	0·926	0·926	0·926	1·308	1·308	1·308	1·308	1·308
Film resistance R_f, C.G.S. units	9·17	8·747	8·397	8·098	7·826	5·839	5·686	5·550	5·425	5·304
Total resistance R, C.G.S. units	10·10	9·673	9·323	9·024	8·752	7·147	6·994	6·858	6·733	6·612
Temperature of internal surface of tube, deg. F.	66·28	72·03	77·40	82·45	87·22	114·45	118·70	122·80	126·75	130·56
Speed of circulating water, ft. per sec.	8	8	8	8	8	8	8	8	8	8
Convective resistance R_r, C.G.S. units	0·650	0·650	0·650	0·650	0·650	0·911	0·911	0·911	0·911	0·911
Film resistance R_f, C.G.S. units	6·397	6·194	6·028	5·870	5·690	4·054	3·978	3·906	3·839	3·777
Total resistance R, C.G.S. units	7·047	6·844	6·678	6·520	6·340	4·965	4·889	4·817	4·750	4·688
Temperature of internal surface of tube, deg. F.	64·38	68·52	72·46	76·12	79·72	113·09	116·08	118·99	121·82	124·58

TABLE VI.—*Condenser Tests by the Brush Electrical Engineering Company, Limited, Loughborough.*

Test number		1	2
Weight of steam condensed per hour	lb.	6,500	6,600
Cooling water, gallons per minute		500	330
Cooling water, temperature at inlet	deg. F.	52	48
Cooling water, temperature at outlet	,,	73	80
Temperature of steam entering condenser	,,	102	84
Temperature observed at air pump suction	,,	65	77
Corresponding partial pressure of air	lb. per sq. in.	0·70	0·11

The condenser had 800 sq. ft. of heating surface. There were 682 tubes ¾ in. external diameter by No. 18 S.W.G., and there were six passes of the circulating water.

The quantity of circulating water given in the Table VI is that deduced by Mr. Newton. From the data provided by Mr. Chilton the present writer makes the quantity to be 512 gallons in trial one and 335 gallons per minute in the second case. These are as close to Mr. Newton's figures as could be expected under the circumstances, and cannot be considered as more accurate. They will, however, be adopted here and the two figures correspond respectively to water speeds of 5·19 and 3·40 ft. per second.

The calculated heat flow per square foot of heating surface was about 8,059 B.Th.U. per square foot per hour in trial 1 and about 8,048 B.Th.U. in trial 2. A mean value of, say, 8,054 B.Th.U. per hour may be accepted as applicable to both trials. It corresponds to a heat flow of 0·6958 calories per second per square centimetre of internal tube surface.

By cross plotting from the figures given in Table V, we get the following values for the temperature of the tube wall when the heat flow is 8,054 B.Th.U. per hour and the mean water temperature is that given in column 1.

Speed of Flow. Ft. per second.		Temperature of tube wall.		
		2.	5.	8.
		deg. F.	deg. F.	deg. F.
Water temperature ..	35 deg.	63·7	50·4	45·2
Water temperature ..	60 ,,	83·2	72·1	68·6
Water temperature ..	85 ,,	104·4	95·0	92·0

Plotting these in their turn we get Fig. 6, page 230,

from which we read off the following temperatures corresponding to a speed of 5·19 ft. per second:

	deg. F.	deg. F.	deg. F.
Mean water temperature	35	60	85
Wall temperature	50·0	71·7	94·7

Finally plotting these figures we get the lower curve shown in Fig. 7. In experiment No. 1 the mean water temperature was 62·5 deg. F. and from Fig. 7 we see that the corresponding wall temperature was 74·0 deg. F.

Having obtained this figure we can get the mean temperature of the steam at the surface at which it condenses, and a comparison of this figure with the temperature at which the steam entered the condenser will show the blanketting effect of the layer of air which collects round the tubes.

The heat flow in experiment No. 1 was, as stated, 0·6964 calories per sec. per square centimetre of internal tube surface. At the external surface the corresponding rate is $\frac{0\cdot6964 \times 0\cdot652}{0\cdot75} = 0\cdot6054$ calories per second per square centimetre of surface. From Callendar's experiments we know that the resistance of the film of water which covers the outer surface of a tube on which steam is condensing, is 2·5 C.G.S. units* so that the temperature drop through this film is $0\cdot6054 \times 2\cdot5 = 1\cdot51$ deg. C. The average rate of heat flow through the wall of the tube is $\frac{0\cdot6964 + 0\cdot6054}{2}$ = 0·6509 calories per square centimetre per second. Taking the conductivity of brass as 0·260 and the thickness of the tube wall as 0·122 cm., we get $\frac{0\cdot122}{0\cdot260} = 0\cdot46$ as the thermal resistance of the tube and the temperature fall through it will be $0\cdot46 \times 0\cdot6509 = 0\cdot30$ deg. C. Hence the total drop of temperature between the inner surface of the tube and the water surface on which the steam actually condenses will be 1·81 deg. C. or 3·26 deg. F. Hence the mean temperature of this surface will be $74\cdot0 + 3\cdot3 = 77\cdot3$ deg. F. The steam temperature at the entrance to the condenser was 102 deg. F. and the corresponding pressure is 1·009 lb. per square inch absolute or 2·05 in. of mercury.

The pressure corresponding to a temperature of 77·3 deg. F is 0·4628 lb. per square inch absolute or 0·94 in. of mercury. Hence on the average the air blanket round the tubes exerted a pressure of $2\cdot05 - 0\cdot94 = 1\cdot11$ in. of mercury and lowered the average temperature of condensation from 102 deg. to 77·3 deg. F. It corresponded, therefore, to a resistance of 22·7 C.G.S. units.

It will be seen that immediately around the tubes there is rather more air than steam. The latter as it condenses falls away as liquid water, but the air which simultaneously reaches the tubes can only get away by convection and diffusion, and the effect of the latter phenomenon is in practice negligible.

The temperature at the air pump suction was in this experiment 65 deg. F. corresponding to a steam pressure of 0·3065 lb. per square inch absolute or 0·62 inches of mercury, so that here the air pressure was 2·05—0·62 or 1·43 in. of mercury, so that in this region there was much more air than steam.

Coming next to experiment No. 2, in which the air leakage had been reduced to a minimum, we find from the curve, Fig. 6, the following values for the wall temperature when the speed of flow is 3·40 ft. per second and the rate of heat flow 8054 B.Th.U. per square foot of external surface per hour.

	deg. F.	deg. F.	deg. F.
Mean water temperature	35	60	85
Wall temperature	55·1	75·8	98·2

These have been plotted as the upper curve in Fig. 7. In this case the mean water temperature was 64 deg. F. and we find from the curve that corresponding wall temperature was 79·3 deg. F. Adding as before 3·3 deg. for the temperature drop between the interior surface of the tube and the surface of condensation, we get 82·6 deg. F. as the temperature of the latter. In this case the steam inlet temperature was 84 deg., so that on the average the air blanket round the tubes now only involves a temperature drop of less than 2 deg. F.

Taking the steam temperature at admission as 84 deg. F., the corresponding pressure is 0·5782 lb. per square inch absolute or 1·18 in. of mercury.

The pressure corresponding to a temperature of 82·6 deg. F. is 0·5524 lb. per square inch absolute or 1·12 in. of mercury. Hence the average air pressure round the tubes is now only 0·06 in. of mercury. At the air pump suction the temperature was 80 deg. F. The result of this calculation appears very satisfactory, and it will be noted that although the formula arrived at includes but one empirical constant, it yields results in agreement with three independent sets of experiments, made

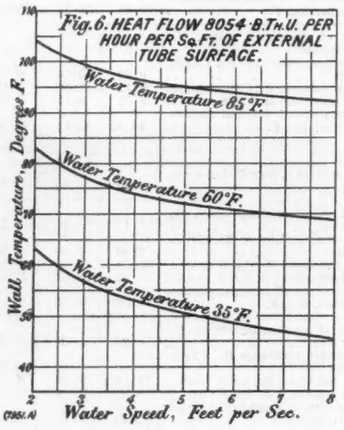
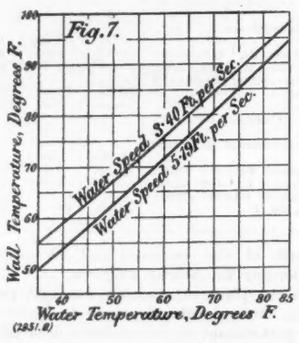


Fig. 6. HEAT FLOW 8054 B.Th.U. PER HOUR PER Sq. Ft. OF EXTERNAL TUBE SURFACE.
Water Temperature 85°F.
Water Temperature 60°F.
Water Temperature 35°F.
Wall Temperature, Degrees F.
Water Speed, Feet per Sec.



by different observers and under widely different conditions. The form of the formula is, moreover, rational, and it cannot, therefore, yield absurd or impossible results, even under extreme conditions.

As mentioned on page 228 *ante*, it is possible to utilise Table V for finding the resistance of tubes of other diameters.

Taking first the Reynolds resistance R_r. Then this is proportional to $\frac{v}{F} = \frac{1}{\rho v L}$, but at a given water temperature, L is the same for two tubes when the product of the velocity and the internal diameter is the same for both.

Suppose, for example, that the tube is $\frac{7}{8}$ in. in external diameter by No. 18 S.W.G. thick. Its internal diameter will be 0·777 in. and hence L will be the same for both tubes if the velocity in the $\frac{7}{8}$ in. tube is $\frac{0\cdot6520}{0\cdot777} = 0\cdot8391$ times that of the other. Thus a velocity of 2 ft. per second in a $\frac{3}{4}$ in. tube corresponds to a velocity of 1·678 ft. per second in the $\frac{7}{8}$ in. tube and at this velocity the resistance R_r of the $\frac{7}{8}$ in. tube will be $\frac{D}{d}$ times the value of R_r for the $\frac{3}{4}$ in. tube at 2 ft. per second. Here D denotes the internal diameter of the $\frac{7}{8}$ in. tube and d that of the $\frac{3}{4}$ in. tube.

Coming next to the film resistance. The thickness of the film in the $\frac{7}{8}$ in. tube will at corresponding speeds be $\frac{D}{d}$ times as much as in the standard tube. To ensure this, however, it is necessary that $\bar{\mu}$ shall be the same for both cases, which will be substantially satisfied if the wall temperature is the same in both cases.

Now at 2 ft. a second, with a water temperature of 60 deg. F., and with a rate of heat transmission of 8,000 B.Th.U. per square feet per hour, the value of t_t for the $\frac{3}{4}$ in. tube was 63·53 deg. F. and the film resistance R_f was 16·68 C.G.S. units. Hence with the $\frac{7}{8}$-in. tube and a water speed of 1·678 ft. per second and the same wall and water temperatures, the value of R_f will be $\frac{D}{d} \times 16\cdot68 = \frac{0\cdot777}{0\cdot6520} \times 16\cdot68 = 19\cdot87$ C.G.S. units. Adding the corresponding value of R_r we get for R the value 22·04. The temperature difference between wall and water being 12·79 deg. C. the rate of heat flow will be $\frac{12\cdot79}{22.04} = 0\cdot5803$ calories per square centimetre per second, which is equivalent to a heat transmission of 6860 B.Th.U. units per square foot of the external surface of the tube.

To sum up:—at corresponding speeds and with the same water and wall temperatures the resistance of a tube of internal diameter D inches is found by multiplying the resistance given in Table V by $\frac{D}{0\cdot652}$ and the corresponding heat flow can then be found by dividing the temperature difference by the resistance thus obtained. This rule is sufficiently accurate for most practical purposes, but it is not quite exact, as owing to the change in the rate of heat flow the temperature t_v of the internal surface of the viscous film will not be quite the same in the two cases. Hence when great accuracy is desired the resistance for another size of tube should be calculated directly.

The argument by which the formula for thermal resistance was established applies to all fluids, but for fluids other than water the formula should read

$$R = \frac{0\cdot45}{s} \cdot \frac{v}{F} + \frac{0\cdot55\,d}{2\,c}\left(1 - \sqrt[4]{1 - \frac{8\,\bar{\mu}\,v}{d\,F}}\right)$$

where s is the specific heat of the fluid traversing the pipe.

To sum up: It has been pointed out that Webster's experiments on heat transfer, indicate that when liquids traverse a hot pipe, we may have a second and hitherto unsuspected critical point, at which the law of heat transfer undergoes a complete change. This change is due to the liberation of dissolved gases in the film which creeps along the inner surface of the tube in viscous flow, and separates the tube wall from the turbulent core occupying the centre of the tube. In the case of water, this liberation of dissolved gases may become pronounced when the wall temperature exceeds 80 deg. C. The effect is to break up the film, thereby greatly diminishing the resistance to heat transfer. It follows therefore that with feed heaters the law of heat transfer may be quite different from that applicable to condensers.

Reynolds' formula for the convective resistance to heat transfer was established in the first article, and corrected in the third, so as to take into account the existence of the viscous film between the turbulent core and the tube wall.

It being known from the theory of dimensions that the ratio of the thickness of this film to the diameter of the tube must be a function of Reynolds' number, the form of the function was determined from physical considerations, and the one empirical constant then comprised in it was deduced, by analysing Webster's experiments. Following this it was shown that the coefficient thus found gave results in accord with experiments made under very different conditions by other observers.

It was also pointed out that in any further experiments on heat transfer it was of first importance to include amongst the measurements, that of the frictional resistance to the flow of the water as this quantity is involved both in the convective resistance and in the film resistance.

* It is of interest to note that this resistance corresponds to an average film thickness of 0·0014 inches; and is thus quite invisible to the eye. The water constituting this film is constantly collected into drops by the surface tension. But what is thus withdrawn is instantly replaced by further condensation.

THE PENINSULAR AND ORIENTAL LINER "MONGOLIA."

CONSTRUCTED BY MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, ENGINEERS, NEWCASTLE-ON-TYNE.

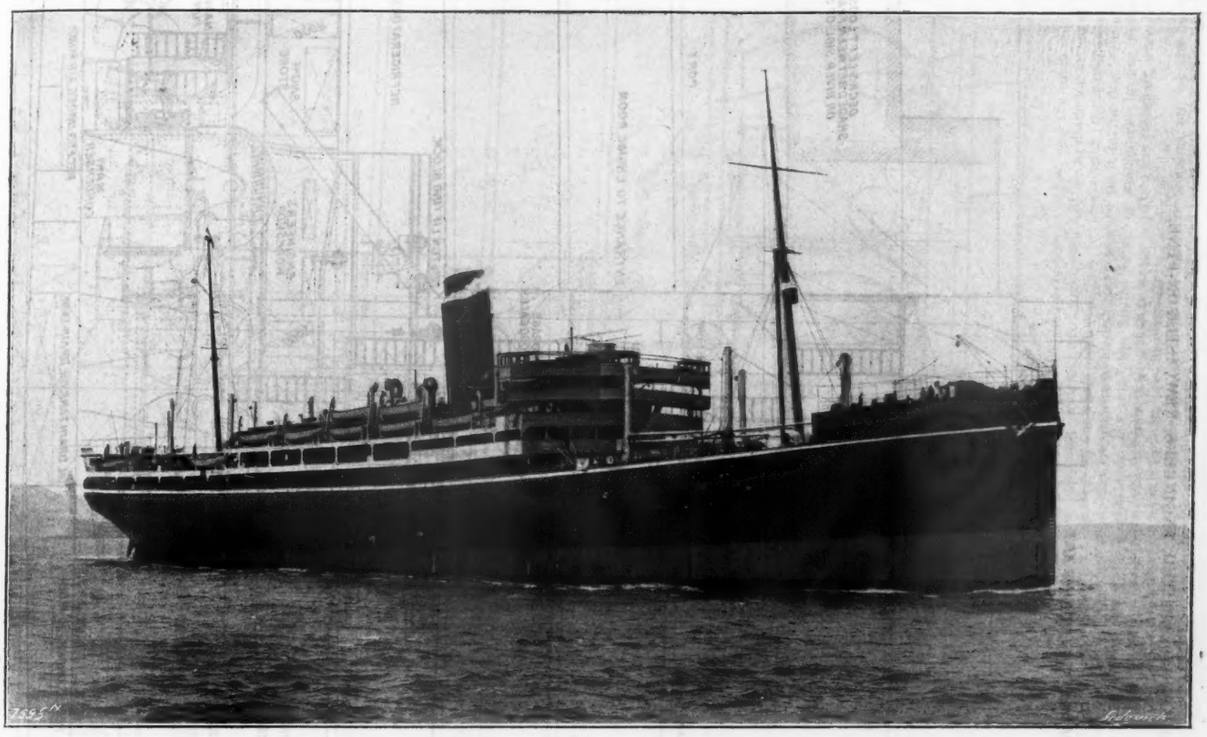


FIG. 1.

THE twin-screw geared-turbine steamer Mongolia, which we illustrate on the present page and pages 232 and 233, and on Plates XV, XVI and XVII, was constructed, at the Armstrong Yard of Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, for the cargo and passenger service, which her owners, the Peninsular and Oriental Steam Navigation Company, Limited, maintain between Tilbury, Australia and intermediate ports. She completed her trials in April last and commenced her maiden voyage on May 11, completing it at Sydney on June 25 without any untoward incident. The Mongolia, we may mention, is the second vessel built by Messrs. Armstrong for the P. and O. Company, the first being the ss. Mirzapore, a cargo vessel of 10,500 tons deadweight, completed at the Walker Yard in 1921. The Mongolia, however, is considerably larger than the previous Armstrong vessel, having a deadweight capacity, when fully loaded to a draught of 30 ft., of 12,050 tons, the displacement at this draught being 24,600 tons. She belongs to the useful and popular class of ship in which on account of the moderate speed demanded (16 knots in the case of the Mongolia) only a relatively small amount of space is required for the propelling machinery and fuel, leaving ample space for the carriage in comfort of a considerable complement of passengers and also for the stowage of a large quantity of deadweight cargo.

The appearance of the Mongolia, which we now propose to describe, is well shown in the photograph reproduced in Fig. 1 on the present page, while the general arrangement of the vessel can be followed by examining the rigging plan and deck plans given in Figs. 2 to 9 on Plate XVI. The principal dimensions of the vessel are as follow :—

	Ft.	In.
Length over all	570	0
Length between perpendiculars	550	0
Moulded breadth	71	9
Extreme breadth	72	0
Moulded depth to shelter deck	42	3
Extreme depth amidships (from top of boat-deck beams at centre to top of keel)	69	0

She has a gross tonnage of 15,55) and a net registered tonnage of 9,550 and is constructed mainly of steel, a cellular double bottom running for the whole length between the peak bulkheads as shown in Fig. 2. The double bottom is adapted for carrying water ballast, oil fuel and reserve boiler feed make-up water, the portions used for these purposes being indicated in Fig. 9. As shown in Fig. 2, the hull is subdivided by 10 main transverse bulkheads extending upwards to the shelter deck, and all the watertight doors fitted in the bulkheads below the water line are provided with the Stone system of hydraulic control enabling them to be closed from the bridge. The vessel, which is classed 100 A1 at Lloyd's and is furnished with a Board of Trade Passenger Certificate, has been built to meet the full requirements of the International Convention on the Safety of Life at Sea. She carries sixteen 28 ft. life boats and two 30 ft. motor boats, the latter being equipped with wireless apparatus and specially fitted for towing the other boats. The boats, which are carried in Welin davits of the latest type, are capable of accommodating about 900 persons, although the passenger and crew number only 696. A Marconi wireless installation, of 1½ kw. capacity, is fitted on the boat deck of the ship.

Accommodation is provided for 230 first-class passengers, 180 second-class passengers and a crew of 286 officers and men, and the whole of the cabins have been arranged and provided with adequate ventilation to ensure comfortable conditions in tropical waters. A number of single-berth and two-berth staterooms for first-class passengers are situated on the promenade deck amidships, as shown in Fig. 4, but the greater part of the first-class accommodation is in the form of two-berth and three-berth cabins on the shade deck amidships and on the forward portion of the shelter deck; the arrangement of the cabins is clearly shown in Figs. 5 and 6. The second-class passengers are all accommodated in three-berth and four-berth cabins on the after part of the shelter deck, and the cabins for the engineers and navigating officers are situated on the boat deck, as shown in Fig. 3.

The public rooms for first-class passengers consist of a dining saloon, music room and smoking room. The dining saloon, which is situated on the shelter deck, amidships, extends for the whole width of the vessel, as shown in Fig. 6, and is capable of accommodating all the first-class passengers at one sitting. It is decorated in the Adams style and finished white. The music room and smoking room are both situated on the promenade deck, as shown in Fig. 4, the former being finished in the Queen-Anne style with Wren detail in polished sycamore. The smoking room is furnished in oak, and the scheme of decoration is Jacobean. The second-class public rooms, which include a smoking room, music room and dining saloon, are all panelled and finished in white, the decorative scheme of the first-mentioned apartment being that of the Tudor period. As shown in Fig. 5, the music room is situated just forward of the second-class entrance on the shade deck, and the smoking room is on the same deck aft of the entrance. The dining saloon is on the shelter deck aft of the engine casing (see Fig. 6), and its capacity is sufficient to accommodate the whole of the second-class passengers simultaneously.

From the rigging plan, Fig. 2, it will be seen that the vessel is provided with seven cargo holds, four forward and three aft of the machinery spaces. Holds Nos. 1 and 5 and the 'tween deck spaces above them, are insulated for the carriage of refrigerated cargo as indicated in the drawing. Large hatchways are fitted to all holds and 'tween decks and a very complete equipment of derricks is provided for the rapid handling of cargo. Particulars of the derricks are given in Fig. 2, and it will be seen from this that one of the derricks fitted to the foremast is capable of lifting loads of 30 tons. For working the cargo, and other purposes, 14 steam winches with 7 in. by 12 in. cylinders and four with 8 in. by 12 in. cylinders, are provided, and the deck machinery includes a Clarke-Chapman steam windlass for 3 in. stud-link cable and four steam warping capstans, two placed forward and two aft. The steering gear is of the steam-tiller type and was supplied by Messrs. Brown Brothers.

In addition to the insulated holds and 'tween decks, special refrigerated store rooms, having separate chambers for the storage of meat, fish, vegetables and other perishable provisions for the passengers, are also provided. The refrigerating plant for the vessel was supplied by the Haslam Foundry and Engineering Company, Limited, Derby, and consists of two sets, one of which is used in connection with the No. 1 hold and 'tween decks, while the other deals with the No. 5 hold and 'tween decks and also with the refrigerated provision rooms, &c. Each set comprises two horizontal CO_2 compressors driven by compound steam cylinders and has its own surface condenser. Both parts of each set form complete units and can be worked independently if desired. The plant is adapted for the carriage of meat, butter or fruit cargoes, the holds for meat and butter being cooled by brine pipes capable of maintaining a temperature of 17 deg. F. below

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Fig. 10. LONGITUDINAL ELEVATION AT C.L. OF SHIP.

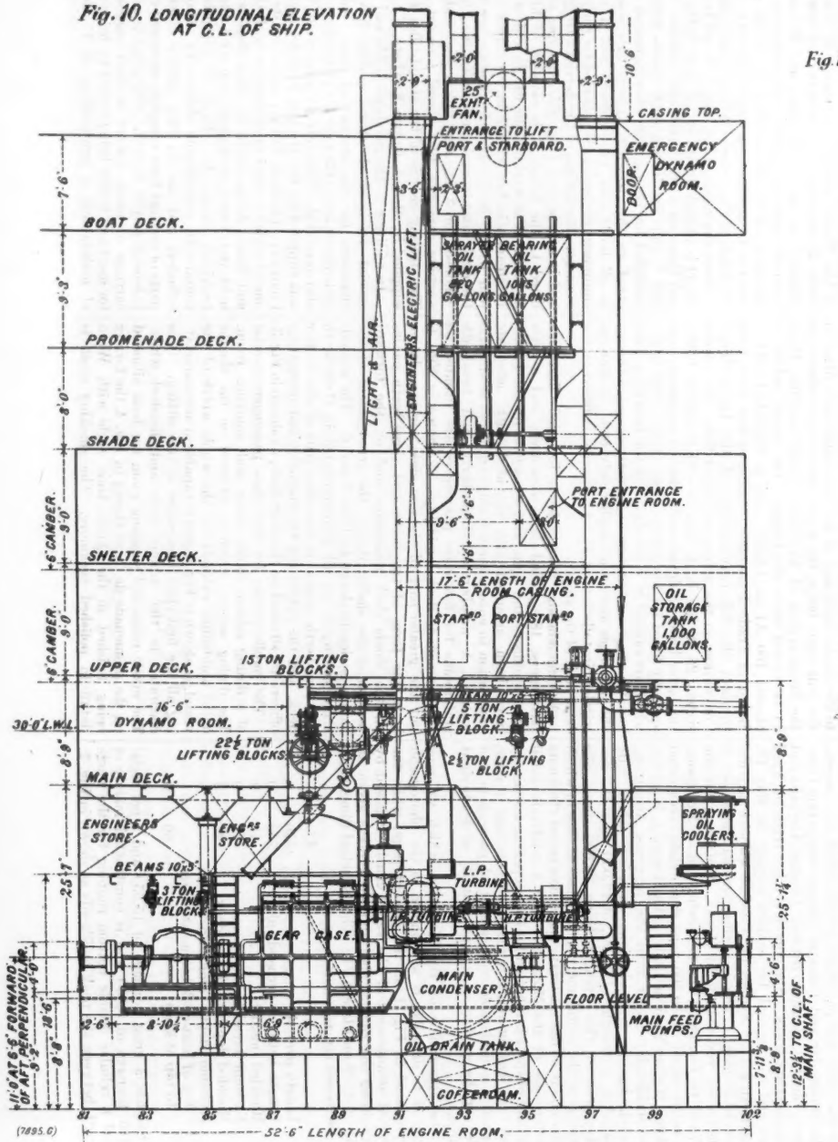

Fig. 11. SECTION AT FRAME No. 96 LOOKING AFT.

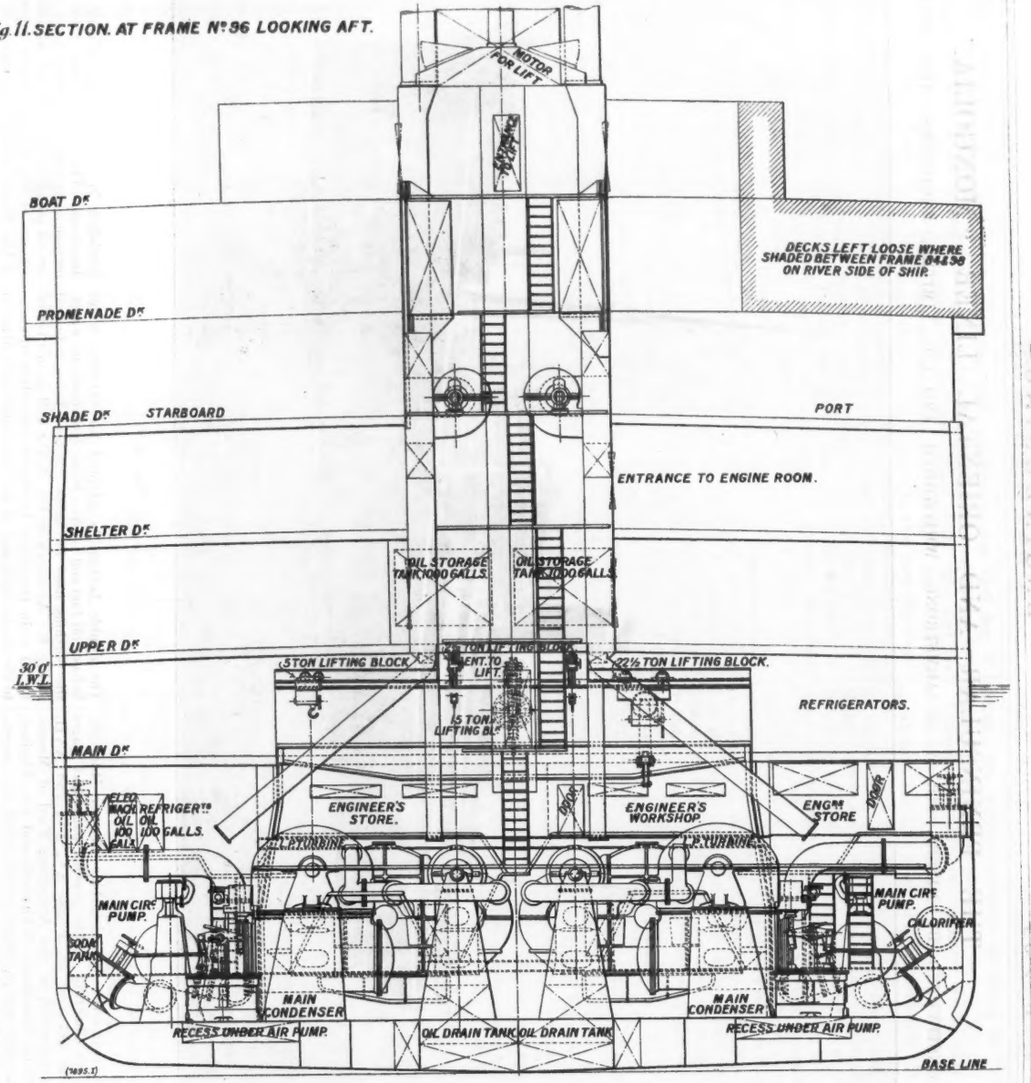

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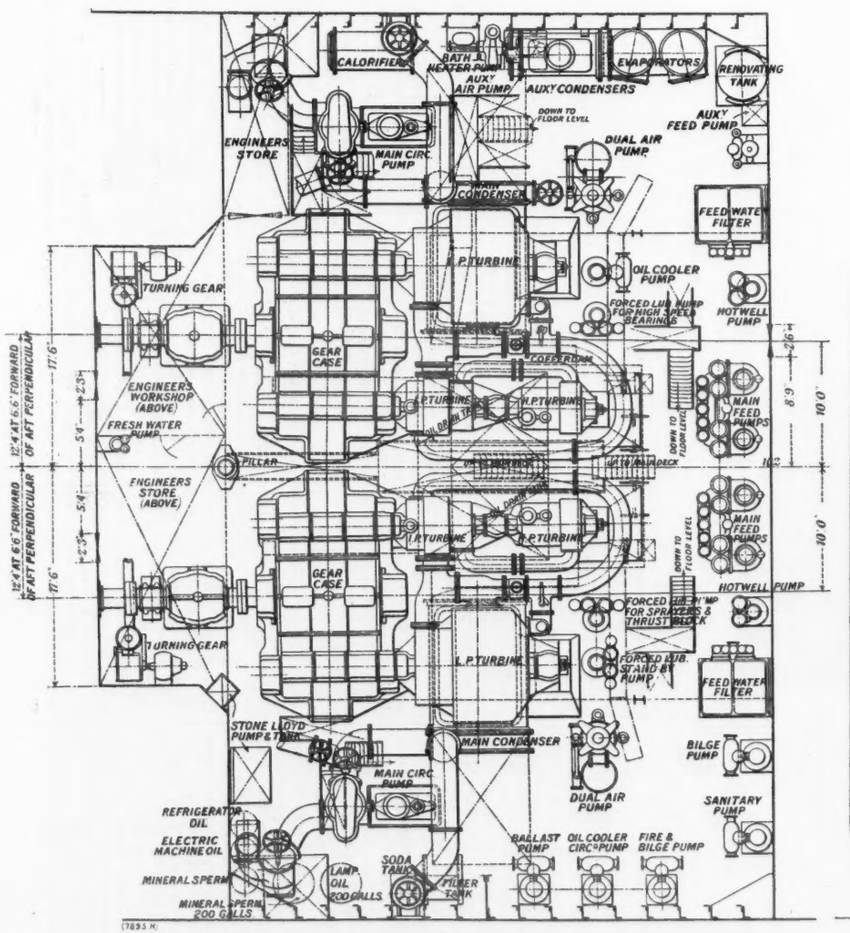
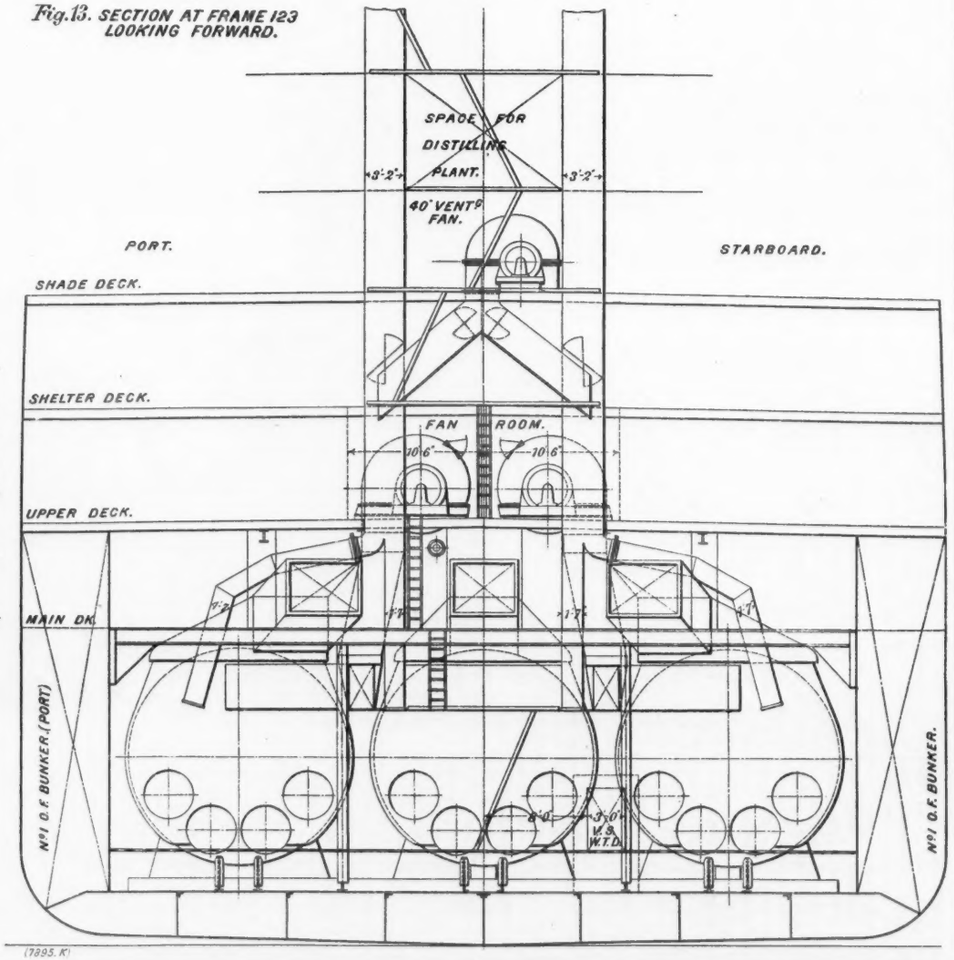
Fig. 12. PLAN BELOW MAIN DECK



(7895. H)

Fig. 13. SECTION AT FRAME 123 LOOKING FORWARD.



(7895. K)

freezing point in the tropics with the machines working from 10 to 12 hours a day. The chambers provided for special cargo, such as wines, cheese, fruit or eggs, are arranged so that the temperature can be kept at any desired figure between 10 deg. F. and 48 deg. F., this being done by supplying the holds with cooled air; the air is delivered to the holds by 35 in. Sirocco fans. Granulated cork, held in position by wood planking, is used for insulation purposes for the whole installation.

The propelling machinery, which was designed and constructed at Messrs. Armstrong's Elswick Works, consists of two sets of turbines driving twin screws at 90 r.p.m. through double-reduction gearing. Figs. 10 to 12 on the present and opposite pages illustrate the general arrangement of the machinery in the ship, while Fig. 17 on Plate XVII shows the two sets in the erecting shops at Elswick. The turbines are of the Parsons type, and each set consists of a high-pressure, an intermediate pressure and a low-pressure turbine developing 6,500 shaft horse-power in all when supplied with steam at 200 lb. per square inch and superheated 200 deg. F. The total shaft horse-power is thus 13,000, and this power is developed continuously under normal conditions at sea. As is most clearly shown in the plan, Fig. 12, above, the high pressure and intermediate-pressure turbines, which run at 2,910 r.p.m., are placed in tandem on one shaft on the inboard side of each set, while the low-pressure turbines are placed on separate shafts on the outboard sides of the sets; the low-pressure turbines run at 1,752 r.p.m. The high-pressure astern turbines are contained in the same casing as the intermediate-pressure ahead turbines, while the low-pressure astern turbines are incorporated with the low-pressure ahead turbines. The astern turbines develop together about 60 per cent. of the ahead power. Thrust blocks of the Michell type are provided, and the main shafting is of forged ingot steel 18¼ in. in diameter arranged in suitable lengths in water-tight compartments. Three-bladed propellers 19 ft. 6 in. in diameter are fitted, the blades being of manganese bronze mounted on cast-iron bosses keyed to the tail shaft, which is 19¼ in. in diameter.

The two main condensers are of the underhung type and are placed beneath the low-pressure turbines, as shown in Fig. 10, page 232. The condenser shells are of steel plate and the water ends of cast iron. Two centrifugal circulating pumps are provided of sufficient

capacity to maintain a 27½ in. vacuum with sea water at a temperature of 85 deg. F. and with the barometer at 30 ins. The pump discharges are 24 in. in diameter and are cross connected so that either pump can supply both condensers if one of the pumps should break down. The circulating pumps are driven by compound vertical enclosed-type steam engines having cylinders 10¼ in. and 18 in. diameter with a piston stroke of 9 in. Two Weir Dual air pumps are provided, one for each condenser, and these are cross connected in a similar manner to the circulating pumps, so that either air pump can exhaust from both condensers if necessary. Wet air pumps draw the condensate from the condensers and discharge it to the feed-filter tanks through filters of the gravitation type. The two feed filter tanks, which are mounted on the engine-room forward bulkhead as shown in Fig. 12 on page 233, are of sufficient capacity to contain the feed water necessary to supply the boilers for 15 minutes when the turbines are developing full power. From the tanks, the water is drawn by two hot-well pumps and passed through a surface heater to the direct-contact heater, whence it is delivered to the boilers by the two main feed pumps. Each one of the latter is capable of supplying the boilers working at full power, while the other is kept as a stand-by.

There are three forced-lubrication pumps in the engine-room, as shown in Fig. 12, one supplying oil for the high-speed bearings of the turbines and gearing, and another supplying that for the gear wheel sprayers and low-speed bearings; the remaining pump is provided as a stand-by for either service. There are two oil-drain tanks situated in the double-bottom as shown in Figs. 10 and 11, page 232, and one of these receives the oil from the high-speed bearings while the other receives that from the low-speed bearings and sprayers. The turbine lubricating pump draws from the former and delivers the oil through duplex filters and change valves to two oil coolers, whence it passes to two gravity tanks placed high up in the engine casing as shown in Fig. 10. From these tanks, the oil flows to the bearings by gravity. The sprayer oil pump draws from the other drain tank and delivers the oil to two separate gravity tanks through a similar arrangement of filters and coolers, but the latter are of larger capacity than those for the high-speed bearing oil in order to reduce the oil for the low-speed bearings and sprayers to a lower temperature. The oil systems from the gravity tanks to the turbines and gearing are independent for the port and starboard sets, and the capacity of the tanks is sufficient to maintain the oil supply for 10 minutes in the event of a stoppage of the pumps. The tanks, however, are provided with floats arranged so that when the oil level falls below the normal, a steam whistle is blown to warn the engineer on watch. Moreover, before the oil supply completely fails, the loss of pressure resulting from the reduction in the quantity of oil in the gravity tanks causes the emergency gear to come into operation and thus shuts off the supply of steam to the turbines. Two pumps, located as shown in Fig. 12, and each capable of delivering 200 tons of water per hour, are installed for circulating water through the oil coolers, and, in addition, a stand-by connection is provided so that water can be taken from the main circulating pumps for this purpose if necessary.

An auxiliary condenser having a cooling surface of 1,000 sq. ft., is provided for dealing with the exhaust from the auxiliary machinery when the vessel is in port. There is a combined air and circulating pump in connection with this condenser and also a vertical simplex feed pump. For the ordinary ship's duties, a ballast pump, sanitary pump, bilge pump and fire and bilge pump, each having a capacity of 200 tons of of water per hour, are fitted in the engine room; there is also a 20-ton fresh-water pump and a Stone-Lloyd pump for the water-tight door system. A salt water calorifier, having a capacity of 2,500 gallons per hour, is provided for supplying hot water for the baths, the water being circulated by a 6 in. by 6 in. by 6 in. pump. The loss of feed water for the main boilers is made up by two evaporators, each capable of producing 40 tons of fresh water in 24 hours.

Steam is supplied by four single-ended and three double-ended boilers arranged as shown in Fig. 13 on page 232 and in Figs. 14 and 15 on Plate XV. A photograph of the three double-ended boilers completed in the Elswick shops is reproduced in Fig. 16 on Plate XVII and the single-ended boilers, with some belonging to other vessels, are shown in Fig. 18 annexed. All the boilers are 17 ft. 3 in. in diameter, the single-ended type being 11 ft. 6 in. long and the double-ended type 20 ft. 6 in. long. The furnaces are all 3 ft. 4 in. in diameter internally and are fitted for burning oil fuel with the Howden system of forced draught, to supply which four electrically-driven fans are provided. The total heating surface of all the boilers is 32,490 sq. ft. Superheaters are fitted to the three double-ended boilers and to the three single-ended boilers placed abreast in the forward part of the boiler room, and these are designed to give 200 deg. F. of superheat to the main steam line and 50 deg. F. superheat to the auxiliary line. CO_2 recorders are provided in the boiler room so that the combustion can be checked at any time.

The oil-burning installation, which was supplied by Messrs. Todd Oil Burners, Limited, consists of two complete units, each comprising three heaters and two vertical oil-pressure pumps. Four heaters and two pumps, however, are sufficient to supply all the burners (40 in number) when the turbines are developing full power. Oil fuel is stored in the double-bottom tanks as indicated on the hold plan, Fig. 9, on Plate XVI and also in side bunkers as shown in Fig. 13 on page 233 and in Fig. 15 on Plate XV. Each of the two setting tanks shown in Fig. 15 has a capacity of 88 tons, and one is used for supplying oil to the burners while the other is being heated for separating any water from the oil. The heating is effected by 2 in. solid-drawn steel pipe coils fitted into the tanks and supplied with steam at 50 lb. per square inch. The steam condensed in the coils is discharged by steam traps into large observation tanks so that the presence of any oil in the condensate can be detected before it is allowed to flow into the auxiliary drain filter and thence into the feed tank. The drain outlets from the oil-fuel heaters and storage-tank coils are treated independently, but in a similar manner. Depth gauges and thermometer tubes are fitted on all the oil-fuel tanks, and the settling tanks and overflow tanks are each provided with a float gauge and electric alarm indicator. The side bunkers are fitted with quick-acting sluice valves. Two oil-filling stations are provided, one on each side of the ship, and there are two transfer pumps, each capable of handling 60 tons per hour, for pumping oil from the storage tanks to the settling tanks; a vertical simplex pump of 30 tons capacity is also provided for dealing with oily bilge water. For fire-extinguishing purposes, a series of perforated pipes is fitted below the boiler-room floor from which low-pressure steam can be discharged, and arrangements are made so that all air inlets can be blanked off by means of louvres. In addition, "Firefoam" hand extinguishers are provided as well as 2-gallon tanks, which deliver fire-extinguishing fluid through flexible hoses.

Special attention has been given to the ventilation of the machinery spaces in view of the vessel's long voyage in tropical waters. Two electrically-driven Sirocco fans supply air to the boiler room, each being capable of delivering 48,000 cub. ft. of air per minute. Two pairs of fans of the same type mounted in the engine casing deliver a total of 48,000 cub. ft. of air per minute to the engine room, the heated air being extracted by exhaust fans fitted at the top of the casing. The arrangement provides for 32 complete changes of air per hour.

The electrical installation consists of five steam-driven generating sets placed in a dynamo room on the main deck level, as shown in Fig. 10 on page 232. Each of the sets, which were supplied by Messrs. Alex. Shanks and Sons, Arbroath, has an output of about 450 amperes at 105 volts. An emergency oil-driven generating set, of 25 kw. capacity, is installed on the boat deck, and this set is capable of supplying current for operating the emergency bilge pump, the wireless installation and for the police and boat-deck lights if the steam plant should be put out of action. In addition to the ordinary lighting equipment a searchlight projector for use in the Suez Canal has been provided and electric fans are installed for the ventilation of all cabins and staterooms, refrigerated spaces, &c., as well as those already mentioned for the supply of forced draught and for the ventilation of the engine and boiler rooms. Motors are also used for the turbine turning gear, for driving the tools in the engineers' workshop, and for operating various lifts and other appliances. There is also a complete installation of electric bells and telephones.

The trials of the refrigerating plant and electrical machinery were successfully completed while the vessel was moored alongside the fitting-out quay at the Armstrong Yard and the trials of the main and auxiliary machinery were carried out on April 26 last, the vessel making a series of double runs at progressive speeds on the Hartley measured mile before proceeding on her voyage from the Tyne to Tilbury. The measured-mile runs, however, were not carried beyond a combined shaft horse power of 6,500, at which power a speed of 14 knots was obtained, since it was arranged for the vessel to arrive at Tilbury in the early hours of April 28 to load for her maiden voyage. Throughout the trials and during the subsequent voyage to the Thames the machinery worked without a hitch of any kind and to the entire satisfaction of the owners' officials and engineers.

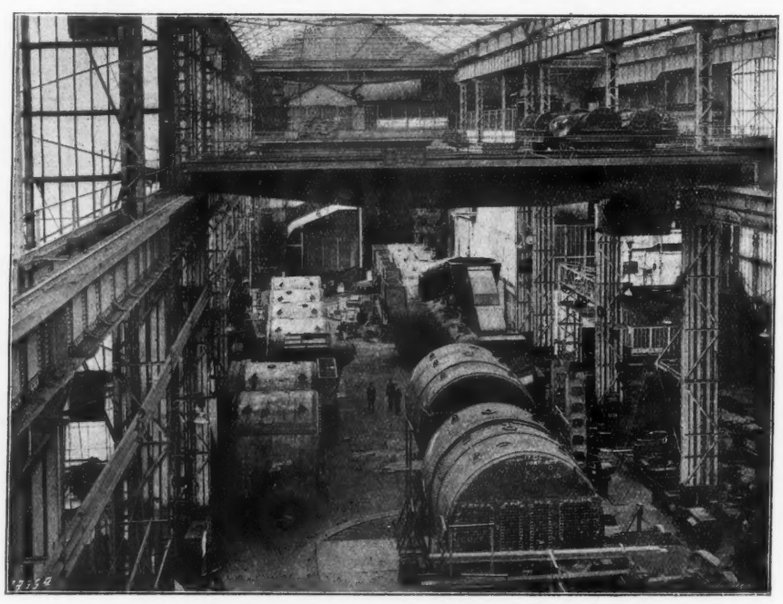


Fig. 18. Single-Ended Boilers.

INDUSTRIAL NOTES.

The National Association of Supervising Electricians, a prominent feature of whose policy has always been the elevation of the standard of technical knowledge among its members, has now inaugurated a scholarship scheme. Three scholarships are to be awarded annually, one to a member below the age of 23 years and the others to members above that age. Although the project was only mooted last July by the President of the Association, Mr. W. E. Highfield, M.I.E.E., the suggestion was energetically taken up by the Council, and a scheme approved which will enable successful candidates to take advantage of the coming sessions which commence in September next. The N.A.S.E., the secretary of which is Mr. A. Brammer, of 82, Victoria Street, London, S.W.1, is doing excellent work in the interests of the skilled foremen and supervisors of the electrical trades, and although its funds do not permit of large awards, the spirit underlying the scholarship scheme is worthy of the highest commendation.

The Ministry of Labour state that employment showed a slight decline, on the whole, during July. The percentage unemployed among workpeople

insured under the Unemployment Insurance Acts in Great Britain and Northern Ireland was 11·3 on July 23, compared with 11·0 on June 25, and with 12·6 at the end of July, 1922. The total number of workpeople registered at the Employment Exchanges as unemployed on July 30 in Great Britain and Northern Ireland was approximately 1,235,000, of whom 936,000 were men and 223,000 were women, the remainder being boys and girls. On June 25 the total was 1,226,000, of whom 934,000 were men and 223,000 were women. The percentage unemployed among members of Trade Unions from which returns are received was 11·1 at the end of July, compared with a similar percentage at the end of June, 1923, and with 14·6 at the end of July, 1922. Among the principal industries, those in which the decline was most noticeable were the wool textile trades, coal and iron mining and the iron and steel industry. Employment was good on the whole in the tinplate, steel sheet, jute and carpet trades; fairly good in coal mining, brickmaking, coach building, and in certain sections of the metal trades; and fair in the paper and printing trades. Some further improvement was reported in brickmaking and building. In most of the other large industries employment was slack.

In the industries for which statistics are collected by the Labour Department, the changes in rates of wages reported as having taken effect in July resulted in an aggregate increase of about 170,000*l.* in the weekly full-time wages of 975,000 workpeople, and in a reduction of over 105,000*l.* in the wages of 835,000 workpeople. The number of workpeople obtaining increases in wages and the aggregate amount of such increases were the largest recorded in any month since November, 1920, and this was the first month since December, 1920, in which the increases reported have exceeded the reductions. The workpeople whose wages were increased were mainly engaged in the mining and iron and steel industries. In the case of coal miners there were increases, ranging from over 2½ per cent. to nearly 20 per cent. on current rates, in Northumberland, Durham, Yorkshire, and the East Midland Area, South Wales, and Scotland. The wages of blastfurnacemen were increased in nearly all the principal districts by amounts varying from over 3½ per cent. to over 14½ per cent. on current rates. There were also increases in the wages of iron miners in various districts, and of iron puddlers and millmen in the North of England and Scotland. The principal groups of workpeople affected by reductions in wages were railway workers and dock labourers. In the case of the former the wages of various classes of traffic workers were reduced by amounts ranging generally from 1*s.* to 4*s.* per week, while dock labourers sustained a reduction of 1*s.* per day or 6*d.* per half-day, on time rates, with corresponding reductions on piece rates. Other large bodies of workpeople whose wages were reduced in July included those employed in the textile bleaching, dyeing, finishing, &c., trades, paper makers, certain classes of workpeople in the printing and bookbinding trades, seed crushing and oil mill workers, and workers in the water and electricity supply industries in various districts. During the first seven months of 1923 the changes in rates of wages reported to the Department have resulted in a net reduction of over 490,000*l.* in the wages of nearly 3,300,000 workpeople, and in a net increase of 280,000*l.* in the weekly wages of 1,050,000 workpeople. In the first seven months of 1922 there was a net reduction of nearly 3,200,000*l.* in the wages of 7,350,000 workpeople, and a net increase of nearly 3,500*l.* in the wages of 18,000 workpeople.

On August 1 the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was approximately 71 per cent. above that of July, 1914, as compared with 69 per cent. on June 30. For food alone the corresponding percentage was 65 compared with 62 a month earlier.

The number of trade disputes involving stoppages of work, reported to the Labour Department as beginning in July, was 37. In addition, 37 disputes which began before July were still in progress at the beginning of the month. The total number of workpeople involved in all disputes in July was approximately 95,000, as compared with 99,000 in the previous month and 46,000 in July, 1922. The estimated aggregate duration of all disputes during July was 1,665,000 working days, as compared with 1,244,000 days in June, 1923, and 443,000 days in July, 1922. The principal disputes in progress were those involving dock labourers at a number of the larger ports and members of the United Society of Boilermakers and Iron and Steel Shipbuilders employed in federated shipyards.

Speaking at the sixth annual conference of the National Federation of General Workers, held at Cambridge, on the 16th inst., Mr. J. R. Clynes, referring to the dockers' strike, said that workers of all grades of labour must find a way to resist wage reductions without having to revolt against agreements which, in effect, they had sanctioned and their accredited representatives were authorised to sign. As a matter of course, the Treaty of Versailles and corollary treaties also came up for discussion. But these, also, are agreements sanctioned and duly signed by all parties to them. Why, then, should the Labour Party countenance any revolt against them?

Representatives of the Transport and General Workers' Union and of the National Union of Railwaymen met in London on Saturday, when they discussed the establishing of machinery not only to eliminate the non-unionists from their ranks, but also to bring about one organisation for the whole of the road transport and railway workers of the country. The following resolution was passed unanimously:—"That this conference, representative of the London and Area Branches of the National Union of Railwaymen and the Transport and General Workers' Union, heartily approves the joint understanding arrived at by the two Executives, and calls upon the Joint Committee to make effective use of the new machinery in dealing with the problem of non-unionists in the railway and other transport services." Mr. W. T. A. Foot, of the National Union of Railwaymen, who acted as chairman, said that the two fundamental causes which had led to the calling of the conference were, in the first place, what was known as "Black Friday" (the defeat, we suppose, of the late railway strike by road transport organisation), and, secondly, the very large steps made during recent years in the organisation of the employing class. The "joint understanding" referred to still does not include the Locomotive Engineers', the Railway Clerks' Association, and probably also other unions connected with transport work. The "Triple Alliance" failed, and other amalgamations may not be more successful. A recent example is afforded by the independent action of the Boilermakers' Society, though formerly part of the Federation of Engineering and Shipbuilding Trades.

The fifty-fifth Trade Union Congress is announced to open in Plymouth, on September 3. Among the points to be discussed is one for a six-hour working day for all workers; this is to be moved by the National Union of Railwaymen. We suggest that the delegates to the Congress should be accompanied by their wives, and that these should improve the occasion by moving for all womenfolk a five-hour working day. Many of them require alleviation of toil much more than do their "lords and masters."

Writing in *The Iron Age*, New York, Mr. G. Walter, of the Milholland Machine Co., Indianapolis, explains how the great American steel industries have come to depend so much upon the foreigner. He says:—"... The foreigner arrives in this country with little or nothing. His head is full of big money easily obtained. Friends soon place him to rights, and when he realises that he must work, and work hard, to get his big money, he goes to work. Long hours and hot furnaces do not deter him; he wants the money and gets it. His work is well done because he knows that his job depends upon it. He believes that seven or eight years over the furnaces will break his health, unless he is possessed of a super-physique, but he has no intention of doing this. A few years' hard work and frugal living, and he has saved considerable money. It requires, however, considerable money to live in the United States, so he either sets up a little business of his own or goes home. This business he owns in its entirety ... He works, his wife works, and his children work helping to keep shop. Had he returned home, his few thousands would have lasted him a lifetime. There he would have told 'how he done it,' and more would have come over ..."

In the matter of the London dock dispute, it was announced at the end of last week that Mr. J. D. Kiley, a former M.P. for Whitechapel, was carrying on negotiations to arrive at a solution. The employers disclaimed that the National Council of Port Labour Employers intended to hold any communication with him or with any other unauthorised parties. A meeting of City business men, convened by the London Chamber of Commerce, was held at the Cannon Street Hotel, when resolutions were passed urging the protection of those men who were willing to work, and denouncing the allowances made by Boards of Guardians to the strikers. Meetings of the strikers were held on Sunday, when it was decided unanimously to resume work last Tuesday morning. There was a reference to a "victory" gained by the strikers. This unofficial strike is, therefore, ended and the men return on the conditions against which they struck about two months ago. One result of their action has been to increase the rates and the cost of living generally. Another result has been the endeavour on the part of the men to form a separate union of dockers, lightermen and stevedores of the Port of London, independent of the Transport and General Workers' Union.

Reports to hand point to the fact that the members of the Boilermakers' Society who are locked out are getting impatient at the duration of the dispute, whilst many of those who are at work resent the extra levy in favour of the unemployed members. Suggestions appear to have been made for a general down-tools policy of boilermakers in support of the locked-out members. The Shipbuilding Employers' Federation have again issued a reply to further allegations made by the Boilermakers' Society, giving the history of the agreement entered into with the Federation of Engineering and Shipbuilding Trades, of which the Boilermakers' Society was a member at the time; the society has since been expelled by the Federation of Trades. There was a breach of obligation on the part of the society. All the allied shipyard trades, the employers add, were observing the full terms of the agreement, whether they were employed on time work or on piece work, and if the boilermakers took up the same position, the dispute could be ended forthwith.

The award by Sir Hugh Fraser in regard to the number of working hours in the building industry has been issued by the National Allied Building Trades Employers and the National Federation of Building Trades Operatives. The award states:—

(1) That the present rule whereby 41½ hours per week are worked during December and January be rescinded, and that the working time of 44 hours per week shall proceed throughout the year, except during the period of summer time, as determined by Statute—approximately 21 weeks (for example, in 1923, on and from April 23 to September 17), when the working time shall be extended to 46½ hours per week by adding half an hour to each of the first five working days of the week.

(2) In December and January, on works where artificial light can be reasonably supplied, the interval of one hour for dinner shall be observed, but in those two months on works where artificial light cannot be reasonably supplied the interval for dinner shall be reduced to half an hour, so that work may terminate during those two months at 4.30 p.m. If, however, on any such works where artificial light cannot be reasonably supplied, the majority of the operatives request that the interval of one hour for dinner may still be maintained throughout December and January, and that the working hours during that period may be consequently reduced to 41½ hours per week, the employer shall be at liberty to arrange accordingly such shortened working hours, this becoming an occasional exception, and not a general rule, as at present.

(3) Nothing in this award shall prevent employers and operatives in any town or area maintaining by mutual consent the 44 hours.

(4) As it is not desirable to interrupt the existing working hours for a brief period of a few weeks during the present summer, this award shall not come into operation until the 17th day of September, 1923.

The National Federation of Building Trades Operatives at its annual conference at Ilfracombe last week passed a resolution instructing the executive to do its utmost to establish one big union for the building industry.

The Admiralty has addressed a letter to the workers' side of the Shipbuilding Trades Joint Council on the question of payment by results, the general adoption of which in the Royal Dockyards, the Admiralty says, would be beneficial to all concerned. The various unions are considering the matter. Numerous examples show that the system has the effect of greatly increasing output and reducing expenditure.

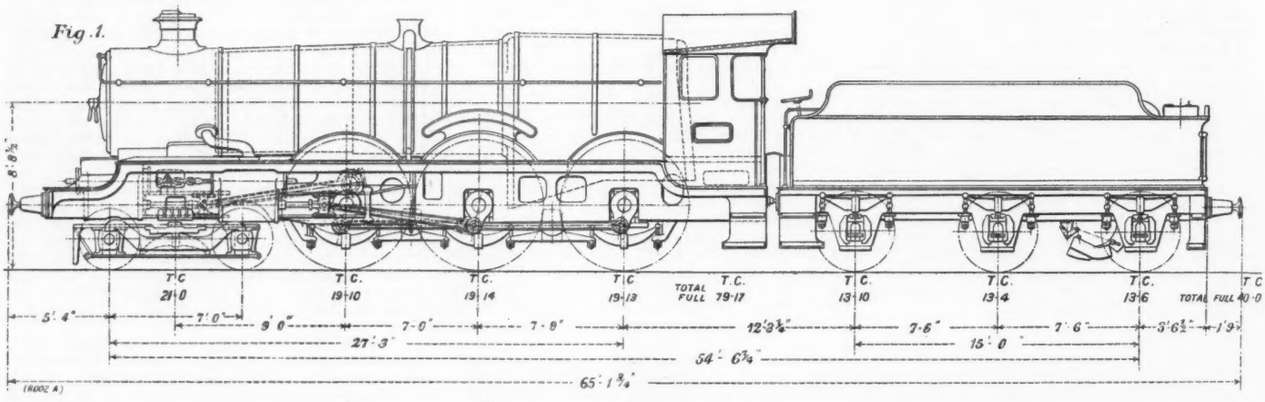
THE ENGINEER'S POCKET TECHNICAL DICTIONARY.—A French-English dictionary for the use of engineers, by Mr. Mark Lvoff, is published by Messrs. E. and F. N. Spon, Limited, 57, Haymarket, at the price of 3*s.* 6*d.* net. It measures 6¾ in. by 4¾ in., and contains 150 pages, giving a large number of general engineering and other words in French, with their English rendering.

TRADE WITH INDIA.—The share of the United Kingdom in the import trade of India rose from 58·5 per cent. of the total in June, 1922, to 61·3 per cent. of the total in June, 1923. As regards exports from India the United Kingdom took 16·5 per cent. in June, 1922, and 22·5 per cent. in June of this year. The shares of Germany in June, 1923, were 6·0 per cent. as regards imports, and 4·8 per cent. as regards exports; 5·8 per cent. of her imports India received from Japan, to which country she sent 14·5 per cent. of her exports; the corresponding figures for the United States were 6 per cent. and 11·8 per cent.

FOUR-CYLINDER 4-6-0 TYPE LOCOMOTIVE; GREAT WESTERN RAILWAY.

CONSTRUCTED AT THE COMPANY'S SWINDON WORKS; MR. C. B. COLLETT, M.INST.C.E., CHIEF MECHANICAL ENGINEER.

Fig. 1.



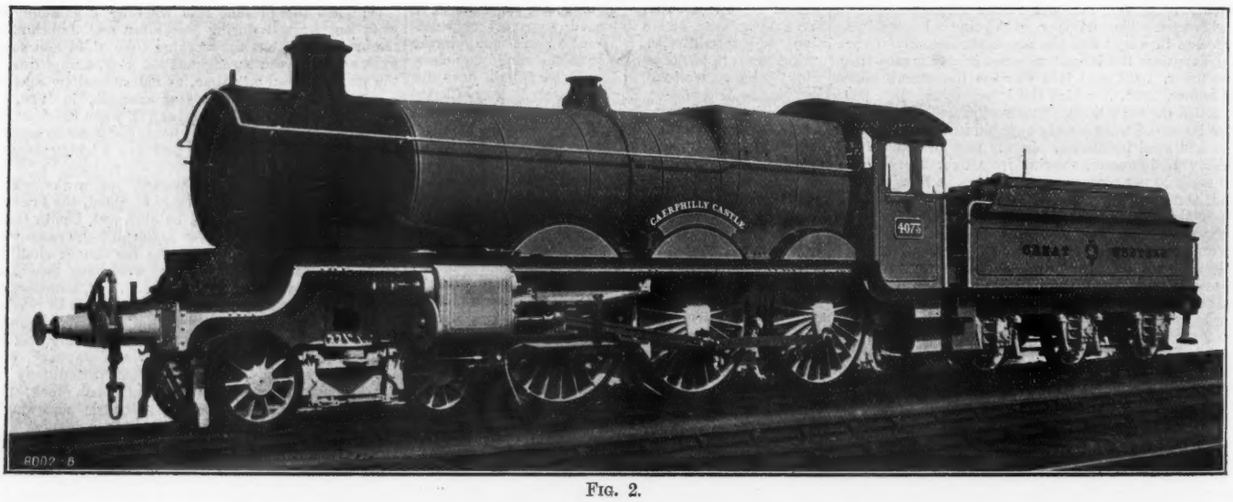


Fig. 2.

By the courtesy of the Chief Mechanical Engineer of the Great Western Railway, Mr. C. B. Collett, we are enabled to give the annexed illustrations relating to a new class of four-cylinder 4–6–0 type of passenger locomotive, the first of which has recently been turned out of the Swindon shops. The class will consist of ten engines in the first instance, and embodies several new features. The new engines have four cylinders, 16 in. in diameter and with a stroke of 26 in. The steam ports are 25 in. × 1¼ in., the exhaust ports being 25 in. × 3 in. Steam passes to the inside cylinders through the saddle casting supporting the smokebox, and to the outside cylinders through steam pipes carried through the side of the smokebox and connected direct to the steam chest. The driving wheels are 6 ft. 8½ in., and the tractive effort at 85 per cent. of the 225 lb. working pressure works out at 31,625 lb., which is considerably greater than for previous Great Western engines of this type, and exceeds that of the large three-cylinder 4–6–2 type express engines on the London and North-Eastern Railway.

To supply the larger cylinders a boiler of increased capacity has been provided, though certain standards are adhered to. The barrel has a diameter of 5 ft. $1\frac{15}{16}$ in. at the front end and 5 ft. 9 in. at the throat. The length of the former standard boiler No. 1, 14 ft. 10 in., is retained. The firebox is of the same design as fitted to Standard No. 7, having a length outside of 10 ft., greatest width of 6 ft. with 4 ft. at the mud ring, the inside measurements being 9 ft. $2\frac{7}{16}$ in., 5 ft. $0\frac{1}{4}$ in., 3 ft. $2\frac{5}{8}$ in. The height is 6 ft. $8\frac{7}{8}$ in. at the front end and 5 ft. $3\frac{7}{8}$ in. at the back. The locomotive is fitted with a superheater of 84 tubes, 1 in. in diameter and 15 ft. $3\frac{3}{4}$ in. long, giving a heating surface of 262·82 sq. ft. The boiler tubes consist of 201 tubes, 2 in. in diameter, and 14 tubes $5\frac{1}{8}$ in. in diameter, their length being 15 ft., $2\frac{7}{16}$ in. These tubes provide 1,882·62 sq. ft. of heating surface, while the firebox furnishes 163·76 sq. ft., or a total boiler heating surface of 2,046·38 sq. ft. The grate area is 30·28 sq. ft. The bogie wheels are 3 ft. 2 in. in diameter. The weights and wheelbases, &c., are given on the diagram, Fig. 1, above.

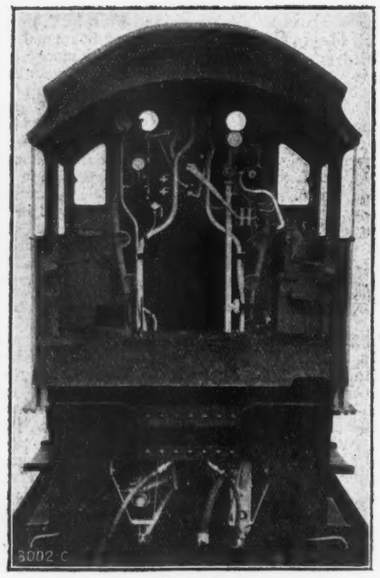


Fig. 3.

The cab provided is a good deal longer than the usual Great Western pattern. A view of the interior is given in Fig. 3. Care has been taken to avoid as much as possible the projection of fittings into the cab, so as to leave more room for the driver and fireman. The roof has been lengthened to give more protection, and side windows are provided, while the men are furnished with tip-up seats.

The tender has a capacity of 3,500 gallons. The total weight in working order of the engine and tender is 119 tons 17 cwts.

10,000-AMPERE OIL CIRCUIT-BREAKER.

An oil-immersed circuit breaker which has a larger current-breaking capacity than any alternating-current breaker yet constructed in this or any other country has recently been supplied by Messrs. Ferguson Pailin, Limited, of Higher Openshaw, Manchester, for a large textile factory in Scotland. The apparatus is designed for controlling a 7,150 k.v.a. three-phase 50-period generator working at a pressure of 525 volts. The breaker is capable of passing an alternating current of 10,000 amperes at 50 periods, or 12,000 amperes at 25 periods continuously, the former current being equivalent to a 25 per cent. overload on the main generator. The installation, which has now been in satisfactory operation for several months, is shown in Fig. 1, page 237. The switch is protected by a brick and concrete cell, in which it is mounted as nearly as possible in line with the machine connections. The heavy and well-laminated conductors are clearly shown. The hand lever seen at the end of the switch cell is provided to enable the switch to be operated in case of any accident to the motor-operating gear.

The appearance of the switch, by itself, will be better understood from Fig. 2. The makers have followed the same practice as in their standard 6,000-ampere circuit breakers, namely, the employment of two breakers working in parallel. A main breaker carries the

10,000-AMPERE OIL CIRCUIT-BREAKER.

CONSTRUCTED BY MESSRS. FERGUSON, PARLIN, LIMITED, ENGINEERS, MANCHESTER.

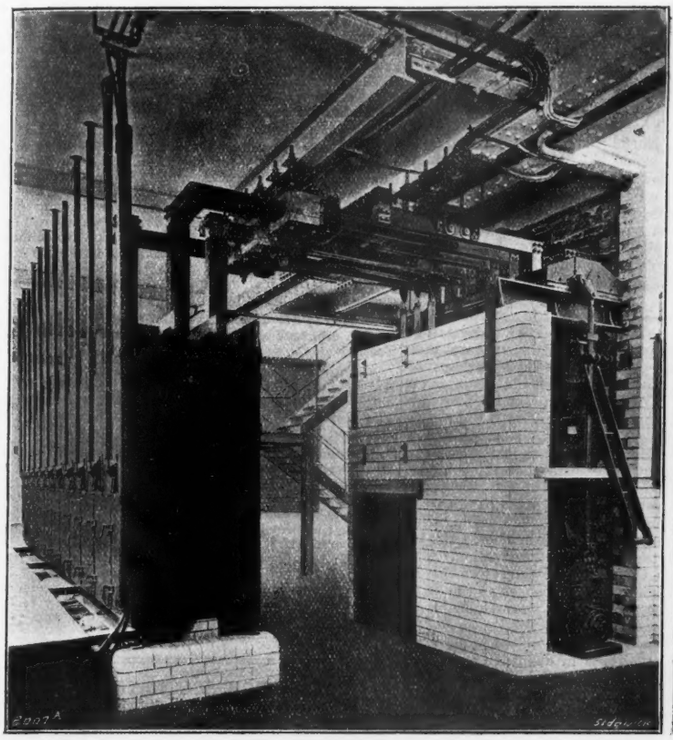


Fig. 1. Switch and Connections Installed.

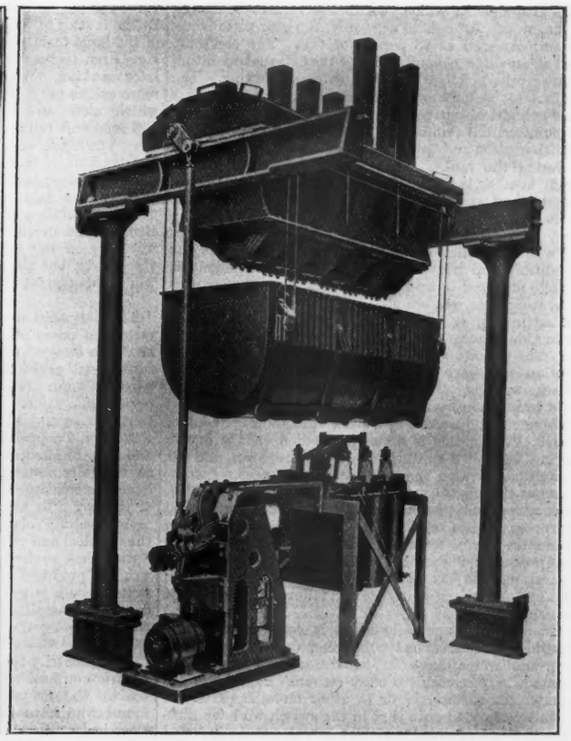


Fig. 2. Switch, with Operating Gear; Tank Lowered.

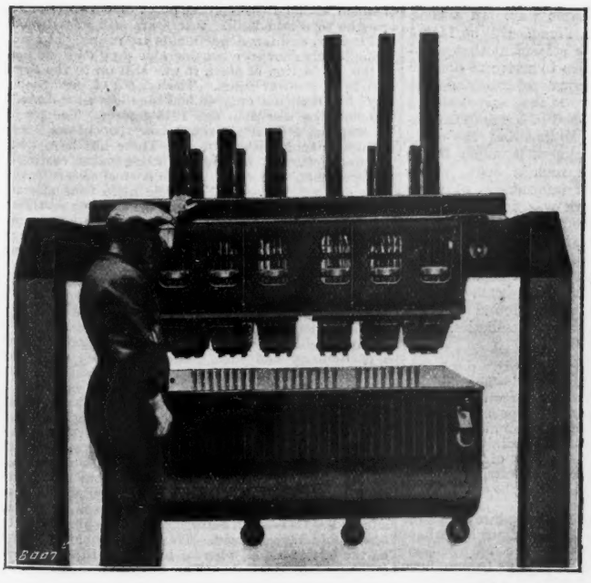


Fig. 3. Main Breaker.

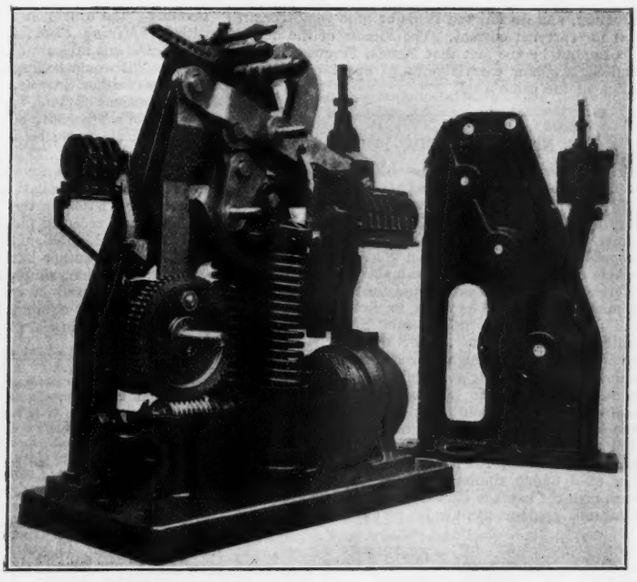


Fig. 4. Operating Mechanism.

current and a snap breaker takes the brunt of the opening and closing operation. The necessity for such an arrangement is obvious, as the moving element of the main breaker weighs more than half a ton, and it would be practically impossible to give sufficient acceleration to so large a mass of metal to ensure a quick and safe rupture of the current. The snap breaker is arranged to make circuit first and break last, so that a short break only is necessary on the main contacts. In opening and closing the switch the light mass of the snap breaker only is moved through a long distance, so that operating power is economised. The illustration shows the combination of the two breakers, together with the motor-operating gear. The timing arrangement between the breakers is quite positive, so that there is no possibility of them operating in incorrect sequence.

The complete breaker, together with its operating mechanism, is supported from one main casting of non-magnetic material. The electrical connections are of laminated copper strip, the individual laminations being 4 in. wide by $\frac{1}{4}$ in. thick. These lead right through the breaker and are sweated and riveted into the solid sectionalised copper blocks which form the fixed contacts. In spite of the fact that current has not to be ruptured at the main contacts, these are fitted with arcing contacts as a precautionary measure.

The moving contacts are lifted by four cams and rollers, the cams moving through 180 deg. in order to get an easy gradient, and being supported by a bearing on the camshaft close to each cam. At the end of the camshaft is a toothed segment which engages with a driving wheel keyed to the external operating shaft. The latter shaft, which carries the remote operating lever, moves through 90 deg. only, the gear ratio being so proportioned as to permit of this. The camshaft and all moving mechanism except the external operating shaft works in oil, which ensures easy working. The main tank is built of strong brass sheet curved to a half-cylindrical shape and fitted with cooling fins. Circumferential reinforcing pieces carry the wheels for transportation and worm and wheel gear is provided for lowering the tanks. The general appearance of the main breaker is shown in Fig. 3. The snap breaker, provided to work in parallel with the main breaker, is a standard 1,200-ampere unit capable of rupturing very heavy currents.

In the installation to which we have referred the conditions did not permit of direct-current solenoids being employed to operate the breaker, so that motor-operating gear was adopted. The mechanism is illustrated in Fig. 4. The motor is connected through a reduction gear to a worm and pinion, and a crank pin on the pinion provides the vertical reciprocating motion necessary for the compression of the main closing springs. These springs when compressed are held in position by a catch lever, which can be tripped by a solenoid operated by a push-button on the control board. When this is done, the stored energy in the springs is thrown on to the main operating rod, and the switch closed with the necessary suddenness. Instantaneous closing, the moment the push-button is pressed, is very necessary, as the switch is used for synchronising purposes. After closing has been effected, a small contactor device restarts the electric motor and again compresses the springs ready for the next closing operation. As has already been indicated, the switch can be hand-operated in case of a failure of the motor or the supply.

In all very large switches it is very important to provide against excessive heating, due to the heavy currents which have to be transmitted across the contact surfaces and to eddy currents induced in the conductors themselves or in other metallic parts. It is satisfactory to note that in the switch we have illustrated the temperature rise in actual service is found to be substantially lower than the 40 deg. Cent. which is permitted by the Engineering Standards Association for oil-immersed breakers rated at more than 2,000 amperes capacity. To obtain this result the joints in the conductors have been reduced to the absolute minimum, and no screwed studs or nuts whatever are used for carrying current. The success of the design is borne out by the fact that Messrs. Ferguson Pailin, Limited, are now carrying out a repeat order for a switch of the same kind.

NOTES ON NEW BOOKS.

The fourth edition of Professor F. C Lea's "*Treatise on Hydraulics*," just published at 18*s.* net by Messrs. Edwin Arnold, covers a very wide field, and does this very satisfactorily from the standpoint of the practitioner and that large majority of students who find themselves interested mainly in what is directly useful. Others will find the work valuable for the copious references to original papers and for the extent of the tabulated matter. The work is distinctly orthodox, and nowhere is new ground broken, but within the limitations fixed by its author the text is from the practical standpoint highly satisfactory. One section is devoted to flow over weirs, in which special attention is deservedly given to the experiments of Bazin, and this is followed by another on the flow through pipes and open channels, after which come chapters on different forms of hydraulic motors and pumps. In the appendix there is a paragraph on the all-important law of dynamic similarity which may, however, we fear, give the average student the impression that the hydraulic gradient can always be expressed as

$$i = \frac{k_0\, v^{2-n}\, v^n}{d^{5-n}}$$

whereas its complete expression may require an indefinite number of such terms with different values of n. The mathematical knowledge demanded from the reader does not extend beyond simple integrations. Nearly 400 illustrations are included in the text, most of which are well selected.

In this country we have always been short of text books on railway economics. America has been better served, and among modern works probably has the best available in the treatises by Byers and Henderson. A very welcome addition to this class of literature originating here has just been made in the form of a volume by Mr. Philip Burtt, whose connection with the North Eastern Railway and with the London School of Economics is sufficient guarantee that the book is on sound lines. Mr. Burtt, in this volume, "The Principal Factors in Freight Train Operating" (George Allen and Unwin, London, 10*s.* 6*d.* net), deals with the subject from the British railway point of view, though he refers to American practice at times. In the matter of train loads the author makes mention of the large trains handled in America, but might have gone even further as regards size if he had referred to later working. We think too that in this connection more might have been said on the high capacity cars which alone make such working possible—cars of 100 tons and 120 tons being now in regular service on the Virginian, and Norfolk and Western, systems. Illustrations of these would have more fittingly found place in these pages than pictures of express passenger engines in a volume on freight operation. However, these are minor points, and the work as intended for British students is an admirable addition to the few we have on the subject. It is largely lecture notes elaborated, but the subject does not lose by the style which this carries with it.

The first edition of a pocket book is very often apt rather to demonstrate how much useful information has been omitted than included, and it is natural that subsequent revisions, made in the light perhaps of friendly comment or of criticism, should be of more permanent value. It is pleasant to know therefore that the second edition of "*Redwood and Eastlake's Petroleum Technologist's Pocket Book*" (Charles Griffin and Co., Limited, London, 15*s.* net) should have been so carefully revised by specialists that its contents have been enlarged by the addition of 100 new pages of matter. In the revision Mr. Eastlake has had the assistance of Professor J. S. Brame, when dealing with the physical and chemical parts of the subject. Mr. W. Sutton has revised the section on production. The work is produced on thinner paper than formely so that its bulk is not increased. A pocket at the back contains a small atlas showing the known oilfields of the world.

The necessity for exactitude in definition can never be over-emphasised, especially on work with a scientific basis. Unfortunately, there are authors still to be found who have failed to recognise this truism. In electrical work especially is this the case. The simple relationships between the ohm, the ampere and the volt are the cause of most of the trouble. Many writers still seem to consider that all that is necessary to define any one of these units is to state its relationship to the others and continue the vicious cycle by "defining" the others in the same way. In a book entitled "*Mining Electrician's Handbook*," by Lionel Fokes, this fault appears after a statement that without units "it would be impossible to arrive at definite conclusions either in calculations regarding design or for extensions of plant." Two of the basic electrical units can, of course, only be defined in terms of dimensions, physical properties and actions and the other deduced from them. This slackness is much to be regretted when it is found in such a book, which is a very useful compilation of information of value to those for whose use the work was designed. The handbook was recently published by Messrs. Thomas Wall and Sons, Limited, of Wigan, at a price of 10*s.* 6*d.* The aim of the author has been to describe the construction, operation, simple testing and repair of the electrical plant used in mining. The hints relating to maintenance of equipment will be found of great service to the men in charge of plant in collieries.

"Aluminium Facts and Figures."—The British Aluminium Co., 109, Queen Victoria-street, E.C., has published under this title a handy vest-pocket booklet, giving the physical properties of aluminium and other metals; electrical and other data on aluminium in bars, strips, wire, strand; sizes and weights of aluminium sheets, circles, tubes; tables of constants, etc. The booklet is issued at the price of 2*s.* 6*d.* by the company.

Personal.—Mr. John Harper Narbeth, late Assistant Director of Naval Construction to the Admiralty, whose retirement, after 46 years' service, we recorded on page 145 of our issue of August 3, asks us to announce that his address is now: "Lawrenny," 65, Sidlescombe-road South, St. Leonards-on-Sea. — Mr. D. Jenkins, M.Sc.Tech., A.M.I.E.E., has relinquished his position as Manager of the Swansea District for Metropolitan-Vickers Electrical Co., Limited, and has entered into partnership with Messrs. P. J. Plevin and Partners, Consulting Engineers, 4, Working-street, Cardiff.—The Keighley Gear Cutting Company, of Fleece Mills, Keighley, have now moved to more commodious premises. This firm, who purchased the gear-cutting business of Mr. Sam Sunderland in October, 1920, have recently completed the erection of an entirely new works, specially built and equipped for the economic production of accurately cut gearing for every purpose. The new address is Aireworth Works, Aireworth-road, Keighley, to which all communications should now be addressed.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—The market is closed for the annual race holidays, and with business practically suspended, there is little new to report. Cleveland pig-iron is in ample supply, but not particularly plentiful. What few transactions are recorded in No. 1 quality are put through at 107*s.* 6*d.* No. 3 g.m.b. remains at 102*s.* 6*d.*, but customers report they can purchase at below that figure. No. 4 foundry is offered freely at 97*s.* 6*d.*, and no difficulty is experienced in purchasing at rather less. No. 4 forge 4, stands at 95*s.* All the foregoing quotations are f.o.t. makers' works, or f.o.b. Tees.

Hematite.—There is a firmer feeling in East Coast hematite, due to reduced production, several furnaces having been put out of operation. The position has improved through stocks having been substantially drawn upon since the curtailed output. Prices are still quite unremunerative, but makers are keeping plant in operation in the hope that the rise in values will continue. Any change in the direction of downward movement in quotations might be quickly followed by more furnaces being laid idle. Nos. 1, 2 and 3 are fully 98*s.* 6*d.* both for home purposes and for shipments abroad, and No. 1 is put at 6*d.* above mixed Nos.

Foreign Ore.—Inactivity continues to characterise foreign ore, and best rubio remains nominally 23*s.* c.i.f. Tees.

Blastfurnace Coke.—Durham blastfurnace coke is still scarce, but local consumers report less difficulty in obtaining supplies, and quotations are a little easier. The concession price of good medium kinds is 40*s.* delivered to regular customers.

Manufactured Iron and Steel.—The finished iron and steel works are closed this week, as is usual during the race holidays. Most descriptions of material are slow of sale, and manufacturers in their anxiety to secure contracts are ready enough to make price concessions. Among the principal market quotations are: Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 14*l.*; steel bridge, ship and tank plates, 10*l.*; steel angles, 9*l.* 10*s.*; heavy sections of steel rails, 9*l.* 10*s.*; fish plates, 13*l.* 10*s.*; and galvanised corrugated sheets, 19*l.* 5*s.*

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The trade barometer is once again on the descending scale, the increase of over 1,000 in local unemployed showing that the slight improvement observable a few months back has received a check. Doubtless the holidays have had much to do with this cessation of activity, but should a strong buying movement not set in next month there is every probability of much of the steel melting plant of the district being brought to a standstill. Prices are still unsatisfactory, fuel is dear, and few departments are running at a profit. Though July showed a considerable drop on June figures in the production of steel, it was still up to the average output of pre-war years. The output of pig-iron, however, has been not only 40,000 tons less than June, but 200,000 tons less than the 1913 figures. The plentiful harvest has altered for the better the outlook in agricultural machinery and tools. There has been quite a welcome return of buying of cutting parts, castings for replacements, and other iron and steel necessities at a time of good harvest. For some little time also there has been an improvement in the demand for scythes and other hand tools required for the farm and the garden. Agricultural engineering firms have not had a good year but they have regained somewhat of the overseas trade cut off when the war broke out. The lack of settlement in Russia and the disturbed state of Eastern Europe have been retarding factors. Development in the use of stainless steel has been rapid, though the higher price has militated against business. Engineering firms are slack, the heavy engineering section especially having a particularly bad time. There has been a decline in the demand for crucible steels and the best qualities of high-speed steel for which Sheffield is famous. The latter trade is suffering not only from the absence of home orders, due to the slackness in the engineering and shipbuilding trades, but to the lack of overseas business. A somewhat curious position has developed in connection with trade with Russia. Enquiries for tools for engineering, agriculture and forestry from that country have been numerous, and had the Russian Government consented to placing orders on terms similar to those adopted before—cash before despatch—substantial business would have accrued. This arrangement worked well on the last occasion, when a large quantity of saws was purchased in Sheffield. The Soviet Government, however, have now declined to agree to the cash proviso and orders have been declined. In contrast to overseas business generally the Colonial market is fairly satisfactory, though demands from South Africa and Canada have fallen short of expectations.

South Yorkshire Coal Trade.—The local coal market presents no new features, and business has been of a very restricted character. Most of the collieries are carrying on under old contracts, and few of the districts are working full time. A fair demand exists for best steam hards on shipping account, but the home market is on the quiet side. A weakness is still noted in requirements for cobbles and nuts. Slacks, however, due to the lessened output, are firm in tone. Little business is being done in house coal. The enquiry for coke is well maintained,

both furnace and foundry qualities continuing in steady request. Gas coke is quiet and prices unaltered. Quotations:—Best branch handpicked, 30*s.* 6*d.* to 32*s.* 6*d.*; Barnsley best Silkstone, 26*s.* 6*d.* to 28*s.*; Derbyshire best brights, 25*s.* to 27*s.*; Derbyshire best house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire best large nuts, 20*s.* to 21*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.*; Yorkshire hards, 21*s.* to 23*s.*; Derbyshire hards, 20*s.* to 22*s.*; rough slacks, 11*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 7*s.* to 9*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—The state of trade in general throughout the country is far from satisfactory. Few or none of the many industries are in a good position at the present time, and the aftermath of the very disastrous years of the great European conflict is telling its tale. The want of demand on all sides is the cause of much of the existing unemployment, and unless a big change takes place soon the outlook for the coming winter will be very serious indeed. The difference between the Boilermakers' Society and the employers which has now existed so long is having a very disastrous effect on the engineering and shipbuilding industries. A sail down the river Clyde from Glasgow, past the numerous shipyards—mostly all idle now—is extremely pathetic and where once all was stir and bustle silence now reigns. Many ships are to be seen partly constructed, and were a settlement of the dispute arrived at quite a large number of workers could be started at work almost immediately. The steel and iron industries are feeling the pinch severely, and from all sides there is the report of nothing doing. The reparations question is having quite a lot to do with the lack of trade at present, and if our own Government and that of France could only manage to arrive at some satisfactory agreement it is generally thought that business would gradually show signs of improvement. All round the prospects are not very bright in the meantime.

Scottish Steel Trade.—The Scottish steel trade continues very quiet and much difficulty is being experienced in giving employment to the small staffs now on the pay lists. Orders are very scarce and old contracts are gradually being run off and little is booked to take their place. Home business is poor and export is rather bad. Some of the black sheet makers have still a fair amount of work on hand but in the hope of securing more export lines the prices have been shaded. Whether or not that will induce more foreign buying remains to be seen. The makers of structural steel are quite busy, and continuous running is assured to a number of firms for a fairly lengthy period. The following are the current quotations:—Boiler plates, 13*l.* per ton; ship plates, 10*l.* per ton; sections, 9*l.* 15*s.* per ton; and sheets, $\frac{3}{16}$ in. to $\frac{1}{2}$ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—Practically no change has taken place in the West of Scotland malleable iron trade over the week and conditions are as bad as ever. The placing of orders would seem to be a lost art as buyers are few and far between. The price of "Crown" bars is unaltered at 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—A quiet tone prevails in the Scottish pig-iron market at the present time, and buyers are not very prominent. The reductions which have recently been made in the prices of foundry grades have failed to bring out much fresh business, and as order books are not in a very healthy condition the outlook is far from good. To-day's quotations are as follow:—Foundry iron No.1, is 5*l.* 7*s.* 6*d.* per ton, and No.3, 5*l.* 2*s.* 6*d.* per ton, both on trucks at makers' yards. The position of hematite iron is unchanged and a very poor demand exists. The price has again been lowered to 5*l.* 7*s.* 6*d.* per ton delivered at the steel works, but even at that figure the reports of fresh orders are not satisfactory. The export side of the industry is not expanding, and although there are a number of inquiries in the market at present the actual tonnage fixed up lately is not very heavy.

Scottish Pig-Iron Shipments.—The shipment of Scottish pig-iron from the port of Glasgow for the week ending last Saturday, August 22, amounted to 1,834 tons. Of that total, 1,090 tons went foreign and 744 tons went coastwise. For the corresponding week of last year the figures were 440 tons foreign and 110 tons coastwise making a total shipment of 550 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Exports of coal from Cardiff, Newport, Port Talbot and Swansea in July, according to the Customs returns, amounted to 2,556,425 tons, or 6,194 tons more than in June. The increased trade, however, yielded a smaller revenue, the total of 3,502,347*l.* being 116,279*l.* less than the total for June. The average *f.o.b.* price per ton of the coal exported in July was 27*s.* 5*d.*, or 11*d.* less than in June and May. The quantity and value of the coal shipped from the principal South Wales ports in July was as follows:—

From—	Quantity. Tons.	Value. £	Price Per ton.
Cardiff	1,441,254	1,942,736	26*s.* 11*d.*
Newport	506,638	687,880	27*s.* 2*d.*
Port Talbot ...	279,291	366,961	26*s.* 3*d.*
Swansea	329,242	504,770	30*s.* 8*d.*

Of the coal exported from Cardiff, 390,029 tons comprised small, which averaged 21*s.* 3*d.* per ton, 17,477 tons through averaging 26*s.* 2*d.*, and 1,033,748 tons large averaging 29*s.* 1*d.* At Newport 121,958 tons of small were exported at an average price of 22*s.* 4*d.*, 10,212 tons through averaging 25*s.* 2*d.*, and 374,468 tons large averaging 28*s.* 9*d.* At Port Talbot the shipments consisted of 104,804 tons of small averaging 20*s.* 6*d.*, 52,079 tons through, averaging 23*s.* 4*d.*, and 122,408 tons large averaging 32*s.* 6*d.* Shipments from Swansea comprised 166,784 tons of small averaging 23*s.*, 13,505 tons of through averaging 21*s.* 5*d.* and 148,953 tons of large, the bulk of which was anthracite, averaging 40*s.* 1*d.* per ton. Steam large exported from Cardiff in July averaged 29*s.* 1*d.* per ton compared with 31*s.* 3*d.* in June and small 21*s.* against 22*s.* 10*d.* Steam large exported from Newport yielded 28*s.* 9*d.*, or 2*d.* per ton more than in June, but smalls at 22*s.* 4*d.* showed a fall of 8*d.* Steam large shipped from Port Talbot averaged 29*s.* 9*d.* compared with 30*s.* 2*d.* in June, and small 20*s.* 10*d.* against 20*s.* 11*d.*, while steam large exported from Swansea averaged 28*s.* 6*d.* or 5*d.* less than in June, and small 20*s.* 7*d.*, a reduction of 2*d.* per ton. Though there is no material alteration in the position of the coal market, business still being conducted on hand to mouth lines, there is a more hopeful feeling that an improvement will shortly take place in the demand in view of the more conciliatory attitude of France over the Ruhr question and on the prospects of a strike of American anthracite miners at the beginning of next month. Meanwhile for prompt business prices continue irregular and on balance easy. Dry large coals and washed duffs are comparatively the strongest section of the market. The former commands round 30*s.* and the latter 26*s.* Best steam large is, however, available from collieries at 30*s.* with Monmouthshires from 27*s.* to 29*s.*, but through contractors supplies can be secured at 1*s.* to 2*s.* less. Best steam smalls are round 21*s.* with coking sorts from 23*s.* to 24*s.*, but inferior dry and steam smalls range from 14*s.* to 18*s.* according to quality. There is an improved inquiry for coke, and it is stated that the Germans are again in the market. At present foundry sorts rule from 47*s.* 6*d.* to 55*s.*, but should the German inquiry mature a sharp advance will probably take place.

German Ship Repairing Work.—The first big German ship-repairing job to be secured by South Wales since the war is now being executed at Hills' Dry Docks, Cardiff, where the Kurt Hartwig Siemers is receiving extensive bottom repairs to damage sustained through running ashore at Lillijungfrau Island, Sweden, in June last.

ITALIAN–AMERICAN CABLE.—An agreement has been signed by the directors of the Italian Cable Company and the Western Union Telegraph Company finally settling the conditions for the laying and management of a direct transatlantic cable between Italy and the United States. Owing to the co-operation which this agreement ensures with the largest telegraph organization in the United States, the arrangement is considered a favourable one for Italy.

SWEDISH INDUSTRY.—The position of the engineering industry has improved of late, as the result of the stabilising of the exchange and the reduction of dumping from Germany. The employment returns show an improvement during the last year. A recent report shows that 325 factories are in operation and the production is 50 per cent. of the capacity. That is an increase of 10 per cent. over the return for last autumn. The improvement is more marked, however, in the mechanical engineering industries, than in the shipbuilding and electrical trades.

THE LATE MR. ALFRED ANGUS SCOTT.—We regret to have to announce the death, which occurred on Saturday, the 11th inst., of Mr. Alfred Angus Scott, of Spring-gardens-road, Heaton, Bradford. Mr. Scott founded the Scott Engineering Company, Bradford, which was afterwards moved to Saltaire and converted into the Scott Motor Cycle Company. Later, he started the Scott Autocar Company, at Lidget Green. In 1915 he gave a demonstration before the King of his machine-gun carrier at Buckingham Palace. Mr. Scott was probably the first to fit a two-stroke engine to a motor launch on the Clyde. For two years in succession, 1912 and 1913, he won the Isle of Man Tourist Trophy race with his machine. Mr. Scott was president of the Bradford Gritstone Club.

TINPLATE PICKLING.—In a note on tinplate pickling published on page 119 of our issue of the 27th ult., and based on the recently-issued Report on Alkali, &c., Works, the remark was made that "size proved the best restrainer of all." Taken alone, this remark is a little too comprehensive, as the report actually compared, in this connection, size with glucose and dextrine. Messrs. J. Wild and Co., Limited, Post Office Buildings, Middlesboro', point out that when the substances compared included Pickelette, this latter material proved, according to the Report, to be the best from certain points of view, and an extensive trial of it was recommended. Messrs. Wild, however, direct attention to the fact that all these trials were made with a 3½ per cent. dose of Pickelette, whereas the standard dose is only 0·15 per cent., which, of course, would greatly lessen the cost of its use. Though some scale is dissolved, Messrs. Wild and Co. contend that the removal of scale with warm dilute sulphuric acid is due to the bursting effect of the hydrogen evolved by the action of the acid on the steel. The credit of first going into the subject of the scientific control of pickling is due to Dr. J. E. Stead, whose results are embodied in booklets published by Messrs. J. Wild and Co.

NOTICES OF MEETINGS.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS: NORTH WALES DISTRICT.—Saturday, August 25, a meeting will be held at Prestatyn in the Council Chamber, at 10.45. Two papers will be read and discussed: (1) The New Prestatyn Sewage Scheme, by Mr. J. Blizard, M.Inst.C.E.; (2) Reinforced Concrete Open-Air Bath and Beach Pavilion, by Mr. Murray Easton, A.R.I.B.A. In the afternoon, inspection will be made of the sewage works, Power house, etc.

INSTITUTE OF BRITISH FOUNDRYMEN.—Saturday, September 1, at 4 p.m., at the College of Technology, Manchester, an address will be delivered by Dr. R. Moldenke, of New Jersey, U.S.A., on "American Foundry Practice."

GEOGRAPHICAL NAMES.—The Permanent Committee on Geographical Names for British Official Use has now issued the second general list of Asiatic names, and the first list of names in Gold Coast and British Togo. From these we take the two following examples: "Kamchatka" is the correct spelling, and not Kamtchatka or Kamschatka. "Kumasi" is correct, and not Kumase or Coomassie. The lists indicate the pronunciation. They are published for the Committee by the Royal Geographical Society, Kensington Gore, S.W.7, at the price of 6*d.*

CIMENT FONDU.—In a recent issue of the *Genie Civil*, particulars are given of tests made with *ciment fondu*, at the Conservatoire Nationale des Arts & Mesures with a view to fixing safe working stresses for this material when used for reinforced concrete. In spite of the higher cost of the new cement, it has already been adopted for reinforced concrete structures in place of Portland cement, since with it the forms and centrings may be removed in three days, so that reinforced concrete buildings may be erected just about as rapidly as corresponding steel structures. Up till the present, the same amount of *ciment fondu* has been used in preparing the concrete as if Portland cement were used, but the experiments made at the Conservatoire Nationale des Arts & Metiers show that it is not necessary to use nearly as much of the new cement as of Portland. The mixtures used in the experiments consisted of 800 litres of gravel, and 400 litres of sand, mixed with 300 kg. of Portland cement, and with either 300 kg. or 200 kg. of *ciment fondu*. Cubes made with the Portland cement tested at three months, broke under a load of 155 kg. per sq. cm., whilst at six months the strength had risen to 163½ kg. per sq. cm. Corresponding cubes of concrete made with the *ciment fondu* concrete had, at three days (not months) a strength of 324 kg. per sq. cm., which in three months had risen to 362½ kg. per sq. cm. Hence, at three days the strength was equal to that of the Portland cement concrete at three months. With the weaker mixture, containing 200 kg. of *ciment fondu*, the strength at three days was 242 kg. per sq. cm.; at three months, 252 kg. per sq. cm.; and at six months, 257 kg. per sq. cm.

THE INSTITUTE OF METALS.—The programme for the autumn meeting in Manchester, from September 10 to 13, of the Institute of Metals, states that the following papers will be read and discussed in the mornings of the 11th and 12th:—(1) "The Cause of Red Stains on Sheet Brass," by Mr. E. A. Bolton; (2) Note on "Brinell Hardness Numbers," by Dr. H. W. Brownsdon; (3) "The Behaviour of Metals under Compressive Stresses," by Mr. H. I. Coe; (4) "On the Measurement of the Change of Volume in Metals during Solidification," by Mr. Hikozô Endo; (5) "The Electrochemical Character of Corrosion," by Mr. Ulick R. Evans; (6) "The Constitution and Age-Hardening of the Quarternary Alloys of Aluminium, Copper, Magnesium, and Magnesium Silicide," by Miss Marie L. V. Gayler; (7) "Investigation of the Effects of Impurities on Copper. Part I.—The Effect of Oxygen on Copper," by Dr. D. Hanson, Mr. C. Maryatt, B.Sc., and Miss Grace W. Ford; (8) "Experiments with some Copper Wire: Cohesion a Function of both Temperature and Cold-Work," by Mr. Douglas H. Ingall; (9) Note on "The Effect of Small Quantities of Nickel upon High-Grade Bearing Metal," by Mr. A. H. Mundey and Mr. C. C. Bissett; (10) "Stereotyping," by Mr. A. H. Mundey and Mr. John Cartland; (11) "Hardness Tests on Crystals of Aluminium," by Mr. Hugh O'Neill; (12) "A Dilatometric Study of the Transformations and Thermal Treatment of Light Alloys of Aluminium," by Mr. Albert M. Portevin and Mr. Pierre Chevenard; (13) Note on "Effects of Rate of Cooling on the Density and Composition of Metals and Alloys," by Dr. R. C. Reader; (14) "Crystallization Effect on Galvanized Iron Sheets," by Mr. E. L. Rhead and Mr. J. D. Hannah (Manchester); (15) "Equilibrium in the System Gold-Zinc (based on Investigations of Electrical Conductivity at High Temperatures)," by Professor P. Soldau (Petrograd, Russia). On Monday, at 8 p.m., Sir Henry Fowler will deliver a lecture on "The Use of Non-Ferrous Metals in Engineering"; the demand for tickets for this lecture has been so great that the hall at the College of Technology, originally selected, has proved too small, and the lecture will be given in the Milton Hall, 244, Deansgate. The other meetings will take place at the Municipal College of Technology. For the convenience of applicants for membership, who are desirous of being elected in time for the meeting, a special ballot is being arranged; in connection with this, membership application forms should be received by the secretary not later than August 30. August 31 is the last day for applying for tickets for the meeting.

THE SÖDERTÄLJE CANAL LOCK.

(*For Description, see Page* 225.)

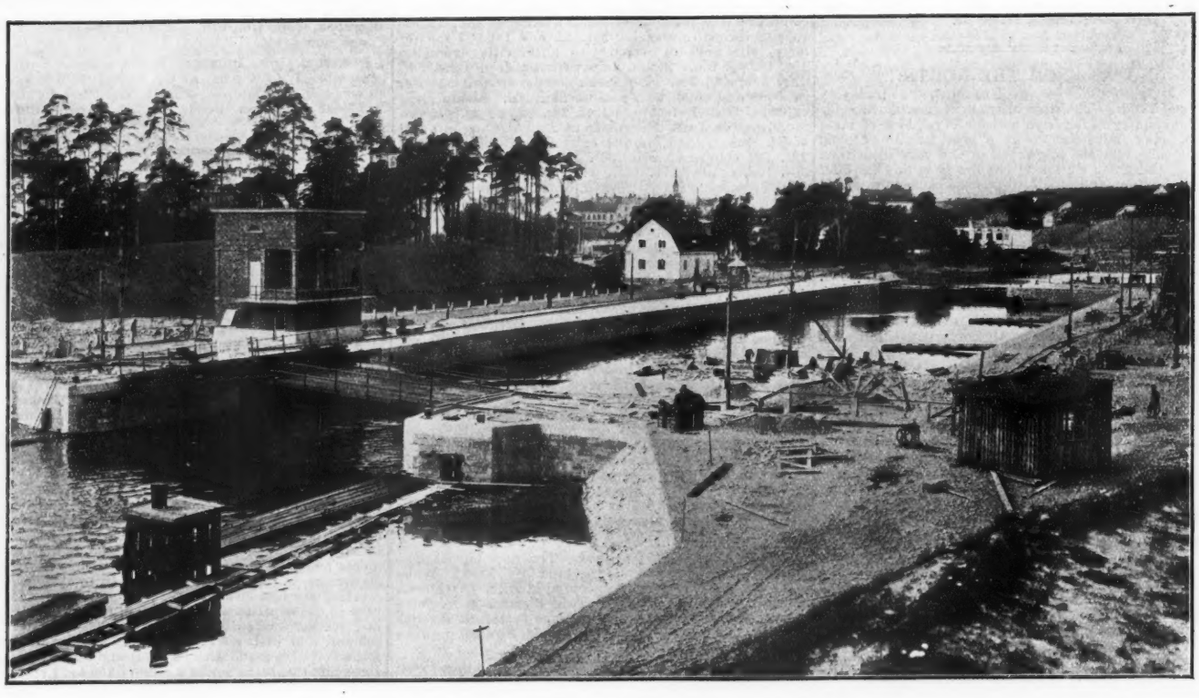


Fig. 11. The New Lock, showing Bascule Bridge and Control Tower.

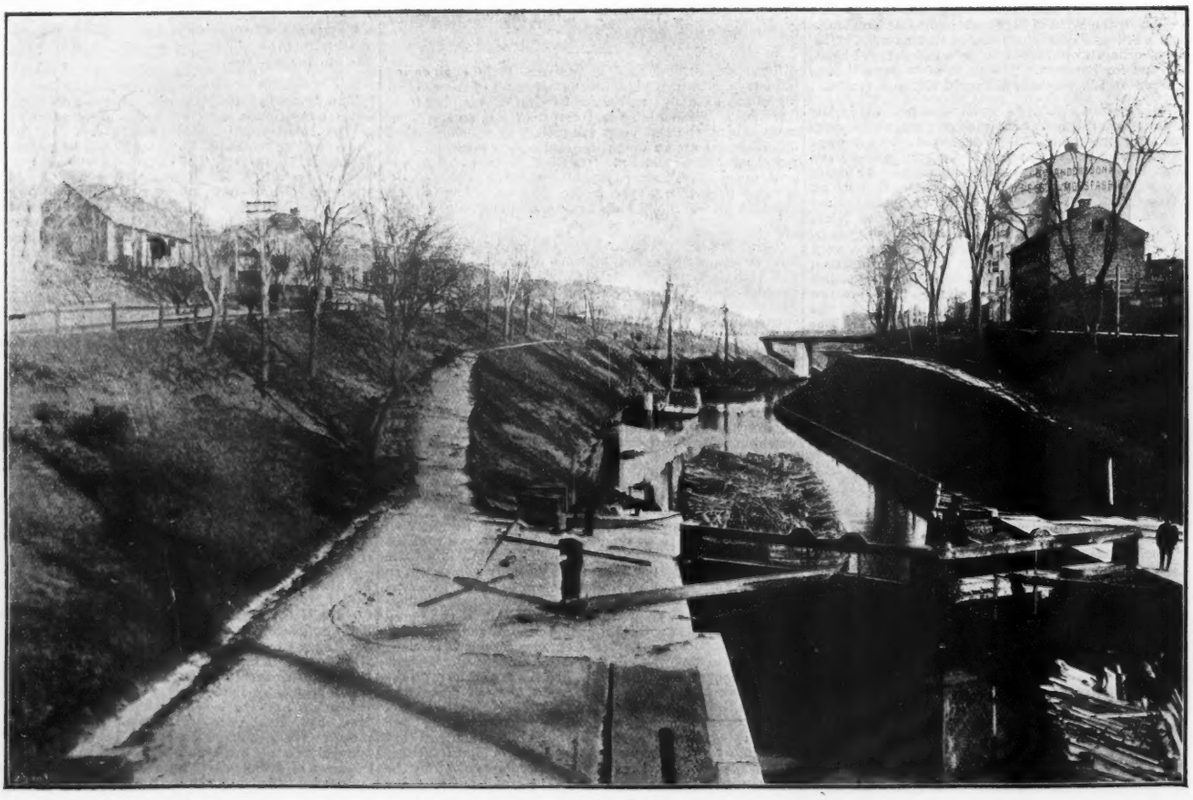


Fig. 12. View of the Old Canal and Entrance to Lock.

MACHINERY OF THE PENINSULAR AND ORIENTAL LINER "MONGOLIA."

CONSTRUCTED BY MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, ENGINEERS, NEWCASTLE-ON-TYNE.

(*For Description, see Page 231.*)

Fig. 14.

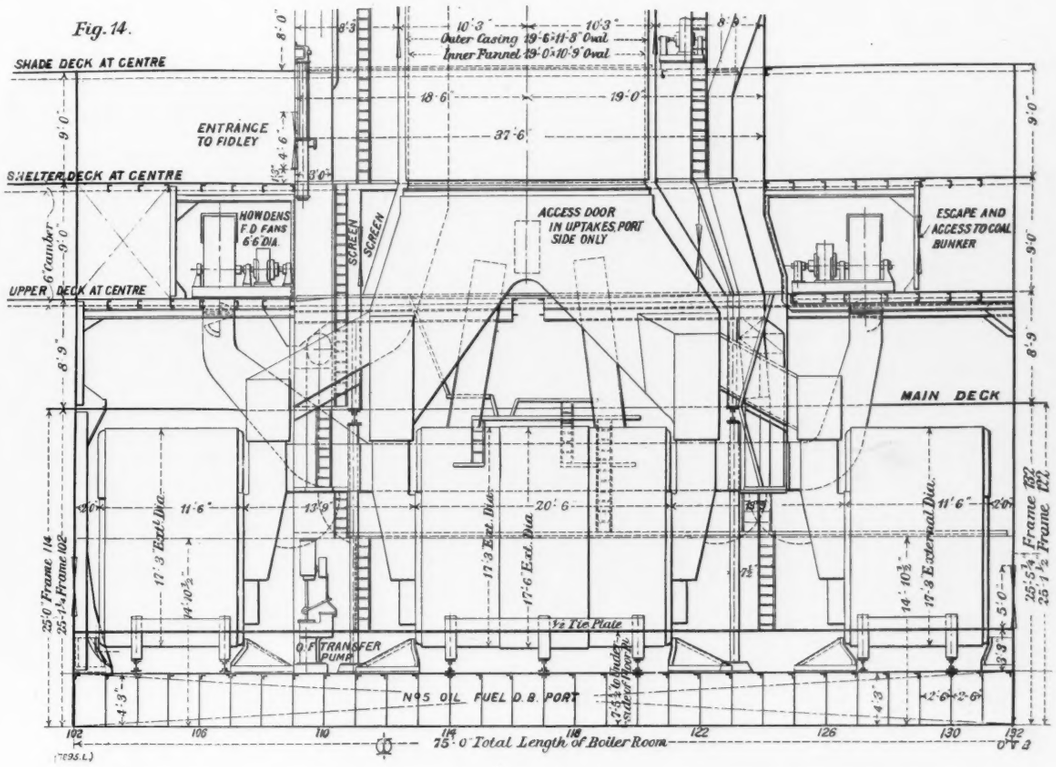
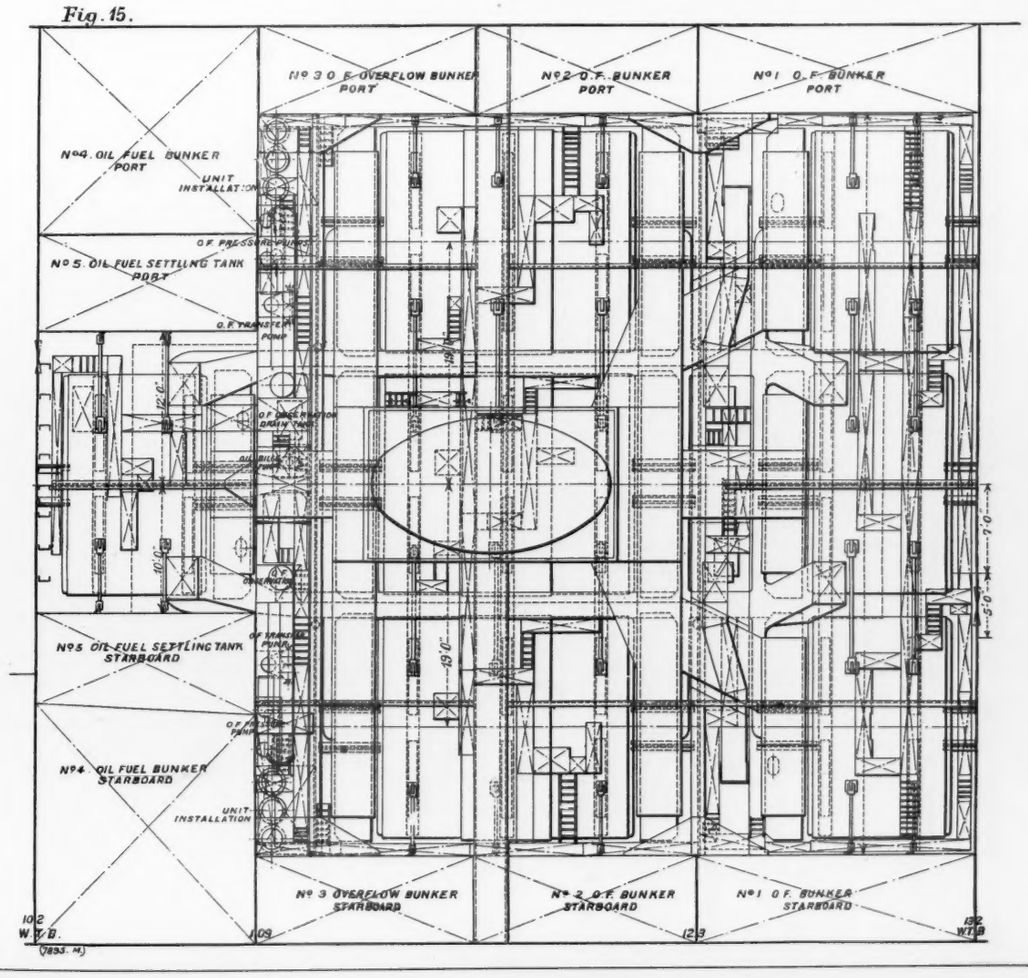

SHADE DECK AT CENTRE
SHELTER DECK AT CENTRE
UPPER DECK AT CENTRE
MAIN DECK
ENTRANCE TO FIDLEY
HOWDENS F.D. FANS 6'6" DIA.
SCREEN
ACCESS DOOR IN UPTAKES PORT SIDE ONLY
ESCAPE AND ACCESS TO COAL BUNKER
Outer Casing 19'6" × 11'8" Oval
Inner Funnel 19'0" × 10'9" Oval
½ Tie Plate
O.F. TRANSFER PUMP
No 5 OIL FUEL D.B. PORT
75'0" Total Length of Boiler Room

Fig. 15.


No 3 O.F. OVERFLOW BUNKER PORT
No 2 O.F. BUNKER PORT
No 1 O.F. BUNKER PORT
No 4 OIL FUEL BUNKER PORT
UNIT INSTALLATION
No 5 OIL FUEL SETTLING TANK PORT
No 5 OIL FUEL SETTLING TANK STARBOARD
No 4 OIL FUEL BUNKER STARBOARD
No 3 OVERFLOW BUNKER STARBOARD
No 2 O.F. BUNKER STARBOARD
No 1 O.F. BUNKER STARBOARD

(*To face page 232.*)

THE PENINSULAR AND ORIENTAL LINER "MONGOLIA."

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(*For Description, see Page* 231.)

Fig. 2. PROFILE

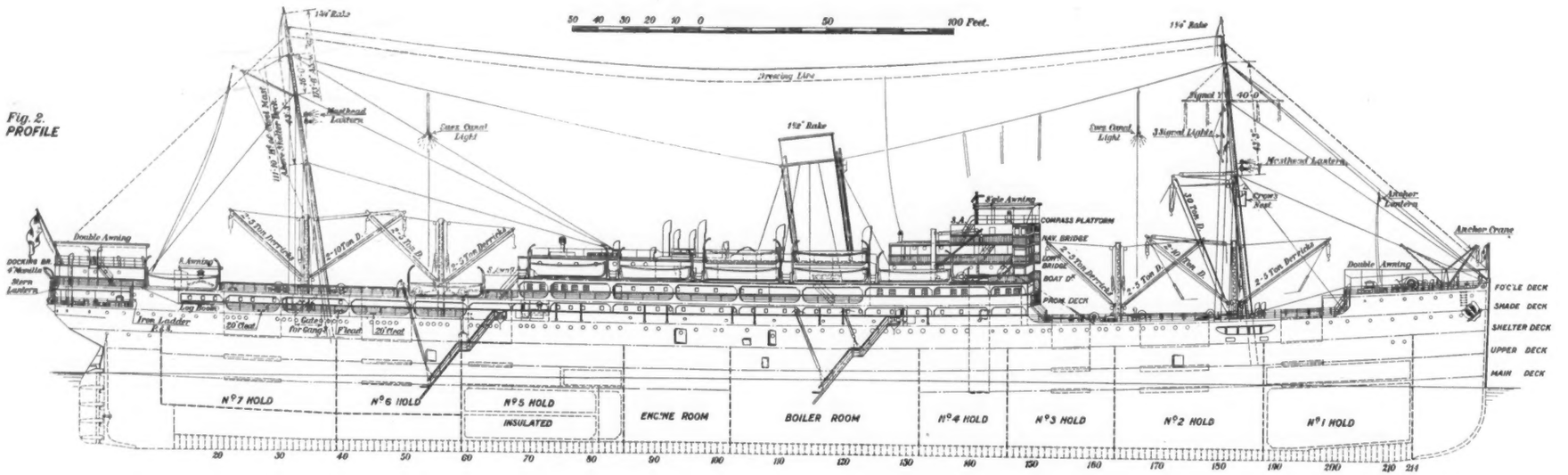


Fig. 3. DOCKING BR. SUN DECK BOAT DECK LOWER BRIDGE DECK NAV. BR. COMPASS PLATFORM

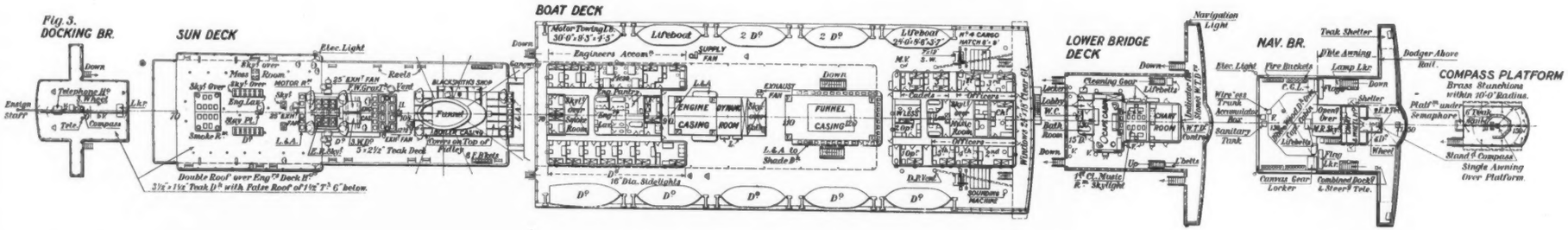


Fig. 4. PROMENADE DECK

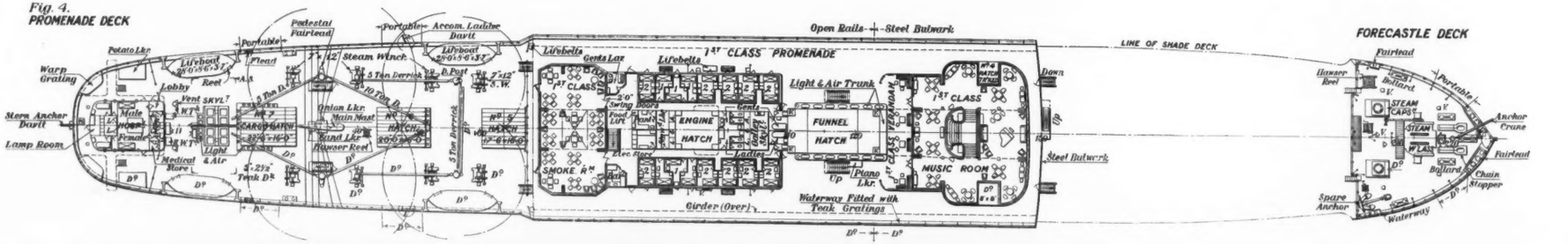


Fig. 5. SHADE DECK

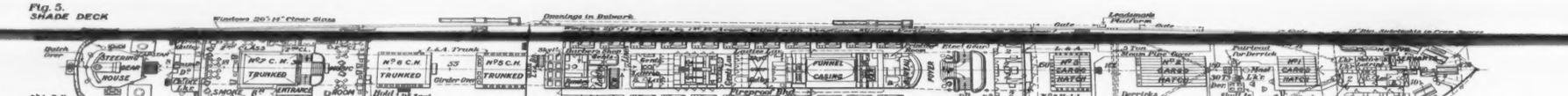
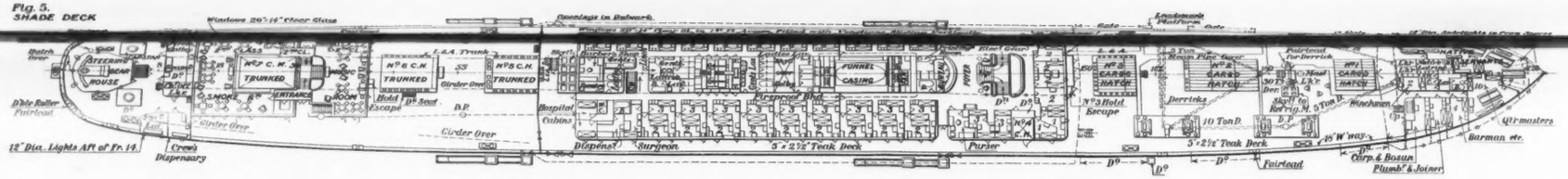


Fig. 5.
SHADE DECK


Windows 26"×14" Clear Glass
Openings in Bulwarks
Steering House
Compass
Engine Room Casing
Hatch over
Skylight
Ventilator
Companion
Engine Room Skylight
Dble Roller Fairlead
Capstan
Bollard
Anchor
Chain Pipe
Cable
Hawse Pipe
Stem
Stern
Rudder
Propeller
Boat Deck
Bridge Deck
Poop Deck
Forecastle Deck
Upper Deck
Main Deck
Lower Deck
Orlop Deck
Tank Top
Keel
Frames
Beams
Stringer Plate
Sheer Strake
Bilge Keel
Bilge Plate
Centre Girder
Side Girder
Floor Plate
Reverse Frame
Bracket
Knee
Deck Beam
Hatch Beam
Pillar
Web Frame
Bulkhead
Watertight Bulkhead
Collision Bulkhead
Fore Peak Tank
After Peak Tank
Double Bottom
Cellular Double Bottom
Longitudinal Bulkhead
Transverse Bulkhead
Shaft Tunnel
Stringer
Gunwale
Scuppers
Freeing Ports
Rail
Stanchion
Awning Deck
Shelter Deck
Upper Tween Deck
Lower Tween Deck
Platform Deck
Inner Bottom
Outer Bottom
Plating
Rivets
Butt Strap
Lap
Scarf
Stem Piece
Stern Frame
Sternpost
Rudder Post
Rudder Stock
Rudder Blade
Rudder Trunk
Propeller Shaft
Tail Shaft
Stern Tube
Thrust Block
Thrust Shaft
Intermediate Shaft
Crank Shaft
Crank Pin
Crank Web
Crank Arm
Crank Throw
Crank Pit
Crank Pit Floor
Crank Pit Bulkhead
Crank Pit Ventilator
Crank Pit Skylight
Crank Pit Hatch
Crank Pit Ladder
Crank Pit Platform
Crank Pit Grating
Crank Pit Guard
Crank Pit Rail
Crank Pit Stanchion
Crank Pit Deck
Crank Pit Bulkhead
Crank Pit Door
Crank Pit Window
Crank Pit Light

MACHINERY OF THE PENINSULAR AND ORIENTAL LINER "MONGOLIA."

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(*For Description, see Page* 231.)

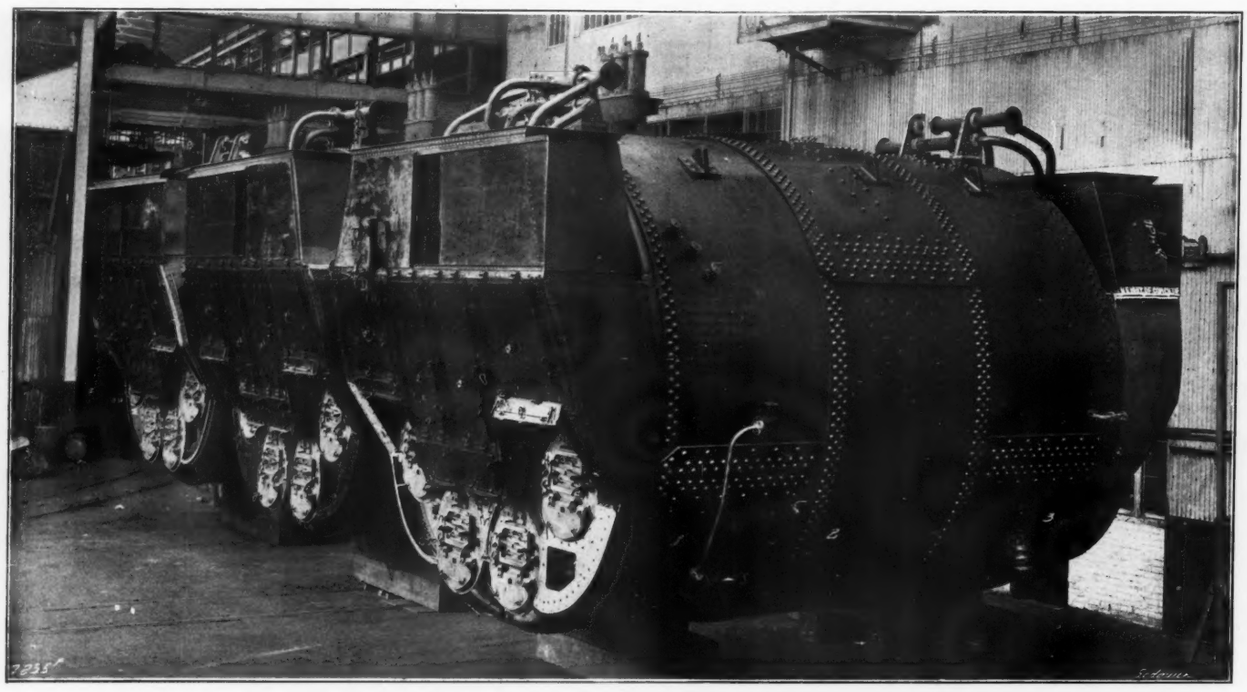

FIG. 16.

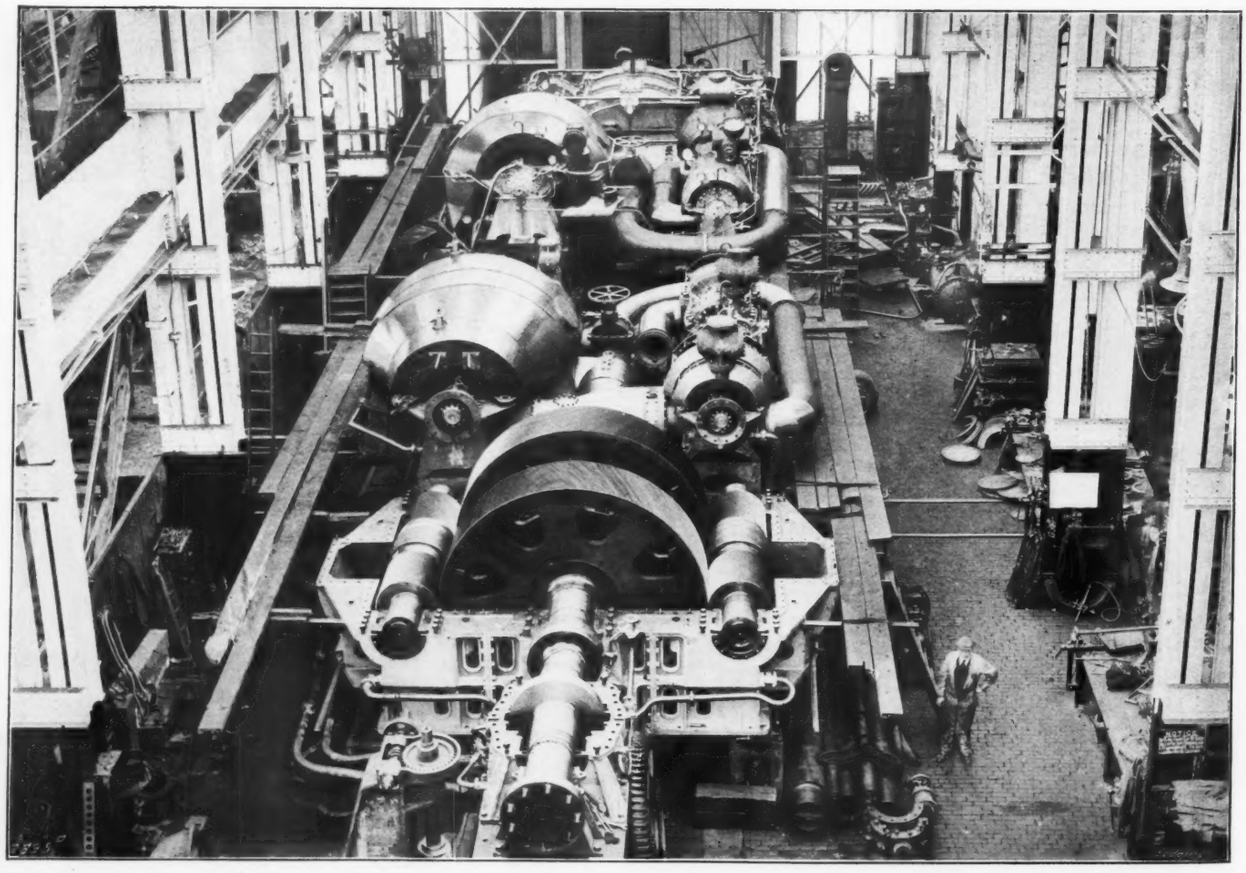

FIG. 17.

(*To face page* 233.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

All accounts are payable to ENGINEERING, LTD. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

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One Two-Page Plate and Two One-Page Plates.—THE PENINSULAR AND ORIENTAL LINER "MONGOLIA."

ENGINEERING.

FRIDAY, AUGUST 24, 1923.

THE PERMANENCE OF CONCRETE.

IT is a common habit when we wish to convey the idea of permanence to refer to rock as the most typical substance to which we can direct attention. Firm, or solid, "as a rock" suggests not only the quality of immovability, but also the characteristic of permanence of structure. Like many graphical phrases there is, however, more of the pictorial in the expression than there should be for strict accuracy, for actually in nature few rocks are so solid and intact as the saying would imply. The "everlasting hills" present masses of rock which are truly impressive, but they are full of fissures and faults, and when we need flawless monoliths we have to search far to find them, the alternative being to dress our material to smaller measures when the idea of monolithic solidity is destroyed. We credit the mountains with an unchangeableness which is far from their due. Compared with their bulk, of course, alterations take place slowly, but every year gives fresh proof of the breaking down of the hardest rock—the slopes are covered by detritus, while the bottoms are filled with finer dusts and sands, also formerly part of the massive natural ramparts above. Even in less rugged districts the decadence is in evidence. The supplies of one of our finest stones—Cornish granite—are side by side with kaolin deposits, the residue of granite decomposed.

No one expresses surprise when it is pointed out that great waterfalls travel slowly up-stream. The forces involved are so tremendous that the idea is accepted. Perpetual wonderment, however, is evinced at the curiously tortuous chasms cut to great depths in many parts of the world by comparatively small streams, as, for instance, are to be found in many parts of the Continent, or, on a rather larger scale, in American canyons. As building materials, natural rocks have often failed us sadly. Stones promising a good degree of durability have proved incapable of withstanding the exposure of their new positions. Frost and moisture disclose unsuspected weak spots or characteristics, and bring about failure, while the atmosphere which we have learnt to produce in our large towns adds one more to the list of destructive agents. Except in certain favoured countries, we rarely find that these materials remain permanently sound. The process may be slow if we are fortunate in our choice, but we are continually busy with repairs to those great national and historic buildings which survive : the lesser examples simply disappear. We build bridges of relatively perishable material, such as steel, taking what steps we may to ensure the maximum practicable degree of longevity, but we admit that these structures are not permanent in the sense in which we apply the term to masonry. Yet in the latter we often have early failures. Sometimes it is the stone, sometimes the bonding. The wider use of concrete with its theoretically monolithic character led to the idea that it would free us from troubles of the latter kind. It was soon found, however, that in order to ensure the monolithic character of such work, great care had to be exercised in the making and placing of the material. Not always assured in the early days, with approved methods bonding difficulties may now be considered to be past, and as practically eliminated.

As regards concrete itself, there is now ample proof in the world that it provides a sound material of very good durability. Many structures have been built which have stood sufficiently long to prove that their life will be excellent. After many years of existence they show no signs of deterioration, and give promise of permanency equivalent, at least, to anything constructed by man, and superior to many of his other efforts. In all conscience a great deal is expected of the material, and its success in the wide range of work to which it is applied is really rather astonishing. In its use in buildings, although exposed intermittently to sun, rain and frost on one side, and to a relatively dry atmosphere and stable temperature on the other, it is perhaps exposed to the least trying conditions we expect it to meet. Many choice building stones fail under these circumstances. We submerge concrete in almost any class of water, salt or fresh, and employ it for structures alternately, submerged and exposed often to excessive heat or frost. We expect it to defy erosive and attritive action, and want it to be impermeable, though many of our ordinary construction materials fall short in these respects. In roads we are applying it in a manner in which it has to comply with very difficult requirements. Road slabs have to withstand all kinds of bending as well as impact, and other destructive forces. The sun arches them in summer, frost curls them up in winter. The surface may be hot and dry soon after a short period of curing, the bottom may remain moist indefinitely. Maturing and contraction take place at different rates throughout the depth, while in prolonged frost the subsoil may freeze and movements of all kinds may take place. All things considered, is it surprising, not that we have some failures, but that on the whole concrete serves us so well ?

Especially is this so when it is realised how little we actually know of the material. By trial and study we have formulated limits within which we must work if we wish to secure results of a lasting nature. Even these do not cover the whole field, while the reason for the ill effect of some slight departure from the approved procedure we are quite at a loss to explain. The chemical combinations and reactions are debateable, and obscure. The period of transition to a final stable form has not been determined, though known to extend over many years. In the United States the setting heat in mass concrete has been found to be still measurable five years after placing. While those points may trouble us little in connection with much of our work, it is realised how little light we have upon these subjects when considering cases of severe exposure, as, for instance, in marine work or the use of concrete in alkali lands.

To meet all the unknown possibilities the general demand is for impermeability as the basis of security. This is, of itself, according to some, a desirable feature, while others argue that it is necessary only because it gives time for the production of stable compounds before water soaks in and affects the salts in their less stable forms. Some go so far as to suggest that a porous structure from which all unstable compounds have been washed out

would, in the end, prove the more reliable. Others, again, recommend additions to the Portland cement of substances purposely introduced to promote the rapid formation of stable combinations.

With these expressions of opinion it is clear that there is a wide divergence of views on the subject. At the recent International Navigation Conference in London, and at a meeting of the American Society for Testing Materials, there was no doubt that the concensus of opinion was that in concrete we had an excellent material of remarkable adaptability, of which, however, it was desirable to have much more knowledge in order to be able to meet with certainty conditions under which in the past it has sometimes, or even often, failed. The direction our efforts have taken have run perhaps too much towards the mechanical side, to making, handling, and placing in which we have achieved no mean success, though there is still something to be done in these directions. The chemical side, however, remains only partly understood.

Cements complying with standard specifications have failed. Others which would not pass these tests have proved satisfactory. The prevailing opinion seems to be that on the chemical side must be sought the lines upon which further advance is to be made. It may be remarked here that a Committee of the Engineering Institute of Canada, studying the deterioration of concrete in alkali soils, has practically abandoned field studies for the moment in favour of chemical investigation. It is the study of the chemical aspect which is behind much of the call for impermeability, and it is this also which has prompted the use of puzzolanic additions, with the object of bringing about at once stable forms of the constituents. This latter system has been so frequently adopted on the Continent in marine works with success, that it is well worthy of research. There is no question here of adulteration, but of the honest addition of an agent believed to have a beneficial effect. This, then, would seem to be one direction which research might take.

We now have specifications which result in a product giving generally, with certain procedure, satisfactory work. They fail, however, to produce material or materials of the range we need in practice. Manufacturers, as well as engineers, are interested in enlarging the field for concrete, and in the production of cements of stable characteristics under the worst conditions. Is it not possible that the future may lead us to apply particular types of cement in different circumstances, instead of, as now, mainly relying upon one specification and different proportioning to cap our efforts with success? Possibly we are now on the threshold of this era, and Ciment Fondu may be the forerunner of a new class of special cements which we shall learn to apply in particular cases. In the matter of metallic alloys we habitually review a wide range before deciding upon any one for some duty we wish to perform. Why should it not be so with cement, if we can enlarge its classes so as to make success assured, rather than problematic, in certain of the conditions under which we would still like to take advantage of the practical features it possesses?

ATMOSPHERIC POLLUTION.

As a guide to the steps which sooner or later will probably be taken to effect an improvement in the atmospheres of our large industrial centres, a detailed study of the whole question of atmospheric pollution is necessary, and such a study is now being carried on by the Advisory Committee on Atmospheric Pollution of the Meteorological Department of the Air Ministry. This Committee has recently issued its eighth report, which deals with the observations made during the year ended March 31, 1922, a considerable part of the report being devoted to the results obtained by the standard gauge for atmospheric pollution, which results have been collected and analysed month by month.

Altogether, 31 gauges have been maintained and operated by 12 authorities in different parts of the country, 8 of the gauges being located in the London area, 9 in Glasgow, 3 in Birmingham, 2 each in Rochdale and Southport, and 1 each in Kingston-upon-Hull, Liverpool, Malvern, Newcastle-on-Tyne, Rothamsted, St. Helens and Stirling. The report gives the results obtained with 22 of these gauges, showing the rainfall, insoluble matter, soluble matter and total solids, the rainfall being expressed in millimetres, and the solids in grammes deposited per square decametre. In all cases the insoluble matter is separated into the headings tar, carbonaceous matter other than tar, and ash, while the soluble matter is classified by loss on ignition and ash. The quantities of sulphates, chlorine and ammonia included in the soluble matter are also indicated. The figures are given for each month of the year, with the mean monthly totals, the totals for the summer and winter months, respectively, and for the whole year, and in many cases the corresponding average figures for the five previous years are included for purposes of comparison.

We have not sufficient space to analyse the figures in detail, but in nearly all cases we notice the total weight of solids collected is distinctly below the average. The year, it will be remembered, was one of exceptionally fine and clear weather, and the atmospheric pollution was doubtless considerably reduced by the enforced fuel economy resulting from the coal strike, which lasted from April 1 to July 4 of the year in question. It is perhaps to be regretted that records have not been obtained from some of the districts especially notable for their murky atmospheres, but of the districts referred to in the report, Liverpool is that in which the greatest weight of total solids was collected during the year. The figure for Liverpool is 21,912 grammes per square decametre, and this is closely followed by that for Newcastle-on-Tyne, where 21,343 grammes were collected in the same area. The atmosphere of Newcastle, however, is usually slightly worse than that of Liverpool, the average annual deposit for the five previous years being 23,482 grammes and 22,431 grammes for the two cities, respectively. The records from the eight gauges in the London area range from 13,972 grammes collected at Archbishop's Park, Lambeth, to 8,511 grammes collected at Ravenscourt Park, Hammersmith, the mean figure for all the stations being 11,088 grammes.

Glasgow, it appears, has a rather better atmosphere than that of London, as far as the deposition of solids is concerned, the mean value of the average figures for the five years prior to 1921–22 obtained from seven stations in that city being 13,083 grammes as compared with 13,913 grammes, which is the corresponding figure for the eight stations in London. For 1921–22 alone the difference is even more in favour of Glasgow, the average figure for the total solids deposited in the seven stations installed in that city being 9,981 grammes per square decametre, or about 1,200 grammes less than the figure previously given for London for the same year. This, however, is probably accounted for by the fact that the effects of the coal strike would be relatively greater in Glasgow than in London. The figures for some other industrial centres for the year 1921–22 are: Rochdale, 20,419 grammes; Kingston-on-Hull, 16,008 grammes; and St. Helens, 15,117 grammes; and these may be compared with an agricultural district such as Rothamsted, for which the figure was 7,213 grammes, and with a health resort such as Malvern, where the low figure of 2,711 grammes was obtained. The figures, in all cases, represent the total solids collected in grammes per square decametre for the whole year.

The three main sources of atmospheric pollution are smoke from factory chimneys and domestic fires, and dust blown up from the ground, or arising from industrial processes. In general it is by no means easy to determine the extent to which these three causes are responsible for the resulting total pollution, but in the case of Rochdale some reasonable estimates have been made by Dr. J. R. Ashworth, this work having been rendered possible by the stoppage of the factories during the coal shortage. Dr. Ashworth ascribes 66 per cent. of the total pollution of the air of Rochdale to factory smoke, 19 per cent. to smoke from domestic fires, and 15 per cent. to dust. These figures may probably be applied without serious error to other industrial districts of a similar character, and they serve to indicate the direction in which considerable improvement might be effected. Although the emission of light smoke is an indication of efficient combustion, it must be admitted that many industrial power plants and furnaces emit more smoke than is necessary.

Factory smoke, of course, nominally comes under the control of municipal authorities, but the latter are generally and rightly undesirous of imposing too severe restrictions upon the industrial concerns which provide employment for the greater part of the inhabitants. Generally the activity of the factories, even if accompanied by the emission of a certain amount of smoke, is of greater economic importance than the purity of the atmosphere. Frequently the prosperity of an industrial community is regarded as inversely proportional to the degree of visibility, and in many townships at the present time the citizens would welcome a little more smoke in the atmosphere, on the assumption that it would be accompanied by increased employment. However, more careful attention to combustion methods, and the substitution of electric driving for isolated steam power plants, would do much to improve the atmospheres of industrial centres, without in any way impeding their activities, and it is in this direction that improvement may be looked for.

In commercial centres, such as London, it is probable that the pollution due to domestic fires forms a much larger proportion of the whole than is the case in Rochdale, and, so far, no legislation exists for dealing with smoke emission from house chimneys. An improvement in the atmosphere of London has certainly followed the more extensive use of gas and electric heating and cooking appliances, the improvement being particularly noticeable during the prevalence of fogs. Still further improvement would certainly result from the widespread use of smokeless fuel, produced by the low-temperature carbonisation of coal, and if this fuel were readily obtainable in sufficient quantities, at a price somewhat lower than that of raw coal, it is probable that the atmosphere of London and other commercial cities would not be greatly inferior to that of an agricultural district.

PATENTS AND ENGINEERING.

The profession and industry of engineering being based to a considerable extent on patents, it necessarily follows that engineers should have at least a good working knowledge of the patent laws of the realm and their application. This applies to inventors and also to firms. To many patent law and practice is obscure. It appears to be, in the words of an old quotation, "a peculiar system of morality veiled in allegory and symbolically illustrated." The peculiar system of morality is due to the fact that letters patent for inventions are the only monopoly in this sense which can now be legally granted under the prerogative of the crown. Those who attempt to put into practice for experiment or otherwise what is described in many specifications at once find that they are veiled in allegory and, indeed, in many cases, that what is described will not effect what is alleged. Illustration by symbols is a common method to be found in electrical and chemical patents. The matter is the more important because of the large number of patents applied for every year, namely, about 30,000. These form potential grants which may prevent others using what is claimed for a term of sixteen years.

Engineering patents as obtained at the present time cover such diverse subjects as motor vehicles, machines for cutting glass tubes, methods of separating dust from air, tipping wagons, internal combustion engines, detachable propelling installations for boats, furnaces, gas producers, alloys, refrigerating plants, heating arrangements, methods of purifying oils and apparatus for treating liquids with gases, these being chosen almost at random from a recent issue of the *Patents Journal*. The number of complete specifications accepted week by week is very much less than the number filed, being about a quarter, which shows that either the inventors have found in working out their inventions that it is not worth while proceeding owing to practical difficulties, or to the fact that the search made by the Patent Office may have shown the invention to be substantially old or that the applications may have been abandoned for financial

reasons. The abandonment of such a large proportion of applications is to be deplored because the publication of specifications undoubtedly does add to the knowledge of the art and assists in some instances to provide the starting point on which research is founded. Again, the grant of patents, besides, if commercially successful, leading to the reward of the inventor, assists in the provision of employment owing to the increase in industry.

There is one aspect often lost sight of, namely, why it is advantageous to proceed to the publication stage with a patent application if possible so that the printed specification may be circulated through all civilised countries either in full or in an abridged form and definitely provide evidence of the priority of the invention associating the name of the inventor with it. This also prevents others at a later date patenting the same device and stopping the original inventor from using it. Many patents at present on the register are unquestionably of doubtful validity to say the least, but while they are in force manufacturers hesitate to carry into effect what they claim in fear of expensive litigation. Unfortunately it is a fact that a manufacturer under these circumstances could be forced to defend an action for infringement brought against him and this action, although perhaps won by him in the Court of First Instance, might be taken to the Court of appeal and to the House of Lords. Not until judgment has been pronounced on a patent by the final tribunal can one safely say whether it is valid or not, and the expense of the procedure certainly causes many to hold the view that modification is required in the laws of the country to deal with the position perhaps on the lines of a patent bar administered by those familiar with technical matters. Whether there should be any change of administration or method of procedure before the patent is granted is a matter which has often been debated.

The Patent Office officials have no authority to consider what is called subject-matter, that is to say, the quantity of invention, or whether a true inventive step has been made by the applicant for a patent. Their duty practically lies in ascertaining whether what has been disclosed is clear and on the face of it sufficient to enable others to carry out the invention on the lapse of the patent, to see that a patent is not granted more than once for the same invention, and to give notice to the public if the carrying out of what is claimed might presumably encroach on the territory covered by some earlier patent or include what has previously been described in a prior specification.

In the United States of America and in Germany the Patent Office examiners have the power to refuse an application if it does not in their view show a decided advance in the art. In this country the opinion at present held is that the Patent Office is not the proper tribunal to consider matters at that length because, in the nature of things, they cannot at the application stage often be supplied with such information, models, or the results of working which ought to be available if they are to come to a proper conclusion.

Apart from that the additional work involved would cause considerable delay to inventors in obtaining the grant of their patents and lead to further congestion in the Patent Office, which is a matter to be avoided in view of the notices officially published at frequent intervals pointing out that delay still arises through the accumulation of work due to the war.

SUBMARINES.

SINCE the signing of the Treaty of Peace at Versailles events in the domains of both domestic and foreign politics have been so numerous, and at times so grave and threatening, as to engage the serious and complete attention of all observers. For this reason the circumstances and discussions which accompanied the formulation of the terms of the Treaty have been almost wholly forgotten, except by those whose particular occupation it is to interpret them. It may possibly be remembered by readers more especially interested in the matter, that either just before or during the meetings of the allied statesmen and experts whose duty it was to draw up the terms of the Treaty it was semi-officially announced that the British representatives had been instructed to press for the abolition of the submarine as a vessel of war.

It might have been anticipated that some such drastic step would have been advocated by the nation whose mercantile marine was far greater in numbers and tonnage than that of any other country, and which had experienced larger losses, both in life and treasure, from the attacks of enemy submarines than any of its allies. The methods adopted by the Germans in the use of their underwater forces had been such as to shock civilised opinion throughout the world, and it was not too much to assume that whilst the results of those methods still remained fresh in the memory of all, the British suggestion would have been widely welcomed and strongly supported. The event proved otherwise, for the reception of the announcement was so cold, and in some quarters so unfavourable, that the British representatives at the conferences either withdrew the proposal altogether, or made no serious effort to secure its adoption.

The reasons for the lack of support accorded the British suggestion are not difficult to find. Primarily it was perhaps a little unfortunate that it emanated from the strongest naval power at the time, and which appeared likely to benefit to a greater degree than others by the adoption of the proposal. Apart from this, it was recognised the submarine had become a fairly efficient weapon of war, and one of which the cost was relatively small compared with other types of warships. To a nation whose financial resources were too limited to allow for the acquisition of a battleship or battle-cruiser costing six to ten millions sterling, the alternative of a flotilla of submarines at a million was a far more attractive, and, at the same time, more practicable consideration. From this point of view the submarine is the naval weapon of the smaller and poorer nations, whose strategy on the sea must usually be restricted to the purely defensive. Moreover, unlike other types of war vessels it can be used with a considerable chance of success against all or any other types including even battlecraft, whose guns are useless against it, and whose torpedo protection is necessarily not a complete one. The moral effect of the submarine is also a factor which cannot be neglected.

From France no support for the suggestion for abolition was forthcoming, for there more lives had been sacrificed and more time and treasure devoted to the development of the submarine than in any other Navy. Nearly 20 years ago the French naval experts, more than satisfied with the progress which had even then be made, predicted the disappearance of the capital ship as soon as the submarine reached its fuller development. The French public, as evidence of its faith in the judgment of its experts, had eagerly subscribed sufficient money to present a submarine to its Navy. French faith in the submarine still survives, and no support for its abandonment came from any quarter.

The Treaty recently concluded at Washington has more clearly defined the methods which submarines may employ against merchantmen in any future war, or at least during the period covered by the agreement, and the adhesion of the five nations represented on that historic occasion has to a large extent removed the British objection to the submarine and compensated for the failure to secure its abolition at Versailles. The cynic, always remembering the few instances in which similar agreements have been broken rather than the far more numerous examples of their observance, will be inclined to place no great measure of reliance on the provisions contained in such agreements when a nation has to fight for its existence.

The preceding remarks have been suggested by several interesting items concerning submarines which have appeared recently in the public press, which indicate that the development of these vessels proceeds apace and that the responsible naval authorities of the nations expect them to take a not inconsiderable part in any future naval warfare. Two obvious features in this development are worthy of notice, and it is proposed to refer briefly to them in the course of the following remarks.

In the House of Commons, on April 25, the First Lord of the Admiralty, replying to a question, stated the submarines now in Commission in the navies of the United States, France, Japan, Italy and Great Britain numbered respectively 76, 41, 43, 43 and 52, but of the last number 12 are in reserve. The additional number which could be put into service if the need arose were United States 26 and Great Britain 7. Actually, therefore, this country has 40 submarines, in full commission, a smaller number than any of the five nations, whilst if all available were in service they would number 59, compared with 102 of the United States.

A second statement as to the number of ocean-going submarines of at least 1,500 tons displacement, 20 knots speed, and 5,000 miles radius of action, completed, building or projected, shows that the United States have three such vessels building and six projected; France and Great Britain have none in any of the three categories; and no information is available as to Japan.

The French naval programme recently adopted includes 12 submarines to be completed during the next five years, in addition to torpedo-boat destroyers and light cruisers, a list which suggests French naval opinion is still very strongly in favour of the submarine and of the torpedo.

It was lately announced that submarine K 26 had been commissioned, having been ordered during the war from Messrs. Vickers, but after the armistice transferred to Chatham Dockyard for completion. Beyond the statement that her surface displacement is about 2,100 tons, no other particulars of the vessel are available, but being numbered in the K class it may be concluded her main features are generally similar to the earlier submarine so lettered. These, for several reasons, were unique craft, being the first of a new type termed Fleet submarines, and also the underwater vessels built during the war in which steam propelling machinery was installed. Many French submarines had been fitted with steam engines, but these were generally of low power not greater than that of the internal-combustion engines of the contemporary submarines of other nations, and developing far less than the 10,000 s.h.p. of the K class.

The reasons for the adoption of steam for this purpose in the two navies were different. For the French submarines the internal-combustion engines originally intended to be fitted were reported as unsatisfactory on the shop trials, and steam was substituted to obviate delay in completion, whilst for the British the oil engines which were available were not sufficiently powerful to obtain the speed desired. Steam engines in such vessels have several disadvantages compared with oil engines, the most important being the larger space required for engines and boilers, the greater fuel consumption per unit of power and consequent reduction in radius of action for a given weight of fuel; and thirdly, the difficulty of making the holes for funnels in the internal or strength hull quickly and efficiently watertight when the vessel is preparing to submerge. The difficulty increases with the power of the engines and the accompanying larger or greater number of funnel openings, but apparently has been satisfactorily overcome in the K class.

The published official return of war vessels completed or building for the British Navy mentions a submarine XI under construction at Chatham, the displacement being nearly 2,800 tons. It is not stated if the propelling engines are of the steam or internal-combustion type, and in fact nothing beyond the displacement is given. The increase in this particular is, however, striking, being 700 tons greater than K 26, and more than four times that of any British submarine afloat in 1914.

As for other types of warships, size is generally dependent on the maximum power of the engines available at the time of the design, and has gradually increased as the internal-combustion engine developed in power. At the outbreak of war, the largest engines of the submarine type, which is different from that fitted in merchant vessels having a greater number of revolutions and being of lighter construction, were of from 600 to 800 b.h.p. in six or eight cylinders, the displacement of the corresponding submarines being from 600 to 800 tons. These figures were applicable generally to all navies.

During the war the development of the Diesel engine in this country was at a standstill, a remark which also applies to the other allied nations. In Germany steady progress was achieved, and

primarily for the purpose of rendering the submarine more effective for immediate war purposes. At the armistice engines developing 300 b.h.p. per cylinder had been installed in a few enemy submarines, and many were available for others which were building. Engines of six, eight and ten cylinders of this power were surrendered to the Allies, and indicated the directions in which improvements had been effected.

It is to be anticipated that as more powerful engines become available submarines will increase in size. This increase has, however, its attendant embarrassments, for on a given financial provision, a limitation which must remain in operation for some years, numbers must be reduced as the cost of units increases. The submarine is a type of vessel which in time of war is most effective when employed in great numbers. Post-war statistics show the greater portion of the damage to allied shipping to have been caused by the smaller types of enemy submarines, and it has been stated by German naval officers that the war was lost to them by the decision of the responsible authorities to proceed with the construction of larger submarines, rather than concentrating on a far greater number of the smaller and what had become the standard, most efficient, cheapest and most quickly constructed types. The development in size of underwater craft will be watched with interest, but it appears probable that although in the immediate future a small number of large submarines will be built, yet the majority of vessels will be of the small type not greatly different from those of 1914. The large type will utilise Diesel engines of increasing power, whilst the engines of the smaller type will be as at present but improved in detail.

Another notable development is the addition of a gun armament. Primarily, the submarine is a torpedo vessel and is most dangerous when navigating submerged and when she can attack with torpedo from any position she chooses and with but small chance of discovery. In 1914, a gun armament was fitted only in a very small number of submarines and was of small calibre and of the disappearing type, thus obviating increase of resistance when submerged. As the war progressed German submarines were at first fitted with small calibre guns for the attack of merchant ships. For this purpose a gun with its small weight of shell and charge was far more economical and efficient than the much heavier and less accurate torpedo. For defence against deck attacks allied merchant ships had to be armed with guns, and those on the enemy submarines were increased in calibre to outrange them. At the conclusion of the war the smallest types of enemy craft were armed with a 3-inch or 4-inch gun, the medium type with two 4-inch, and the largest with one or two 6-inch. Guns were also fitted in Allied submarines but usually of a smaller calibre, except in the British M class where a 12-inch gun was mounted.

The American ocean-going submarines previously referred to are to carry one 5-inch gun, and a correspondent of one of the London newspapers has reported that submarine XI will mount a large gun, probably a 12-inch. The gun armament of submarines is thus becoming an important feature, although the original purpose for which it was fitted in German submarines will have disappeared if the provisions of the Treaty of Washington which are applicable to the treatment of hostile merchant ships are to remain in force. Defence against enemy aircraft can be more efficiently met by guns of much smaller calibre than those which have been mentioned, and it would thus appear that in the future it is anticipated submarines will be employed in gun duels against surface warships. Already the submersible monitor is in existence in the British M class with a single 12-inch gun, and the indications point to the development of the submarine in the direction of submersible cruisers and battleships. Is the air menace driving the fleet below the surface?

The naval authorities of the nations allow few details of new submarines to be published, and it is probable there are developments in particulars other than those which have been briefly referred to in the preceding remarks. But even if the evolution of these craft proceeds only in those two directions the details of future submarines will be scanned with increasing interest.

THE APPROACH OF FLAT ELASTIC PLATES UNDER LOAD WHEN SEPARATED BY A BALL OF SIMILAR MATERIAL.

By John Goodman, Emeritus Professor of Engineering, The University, Leeds.

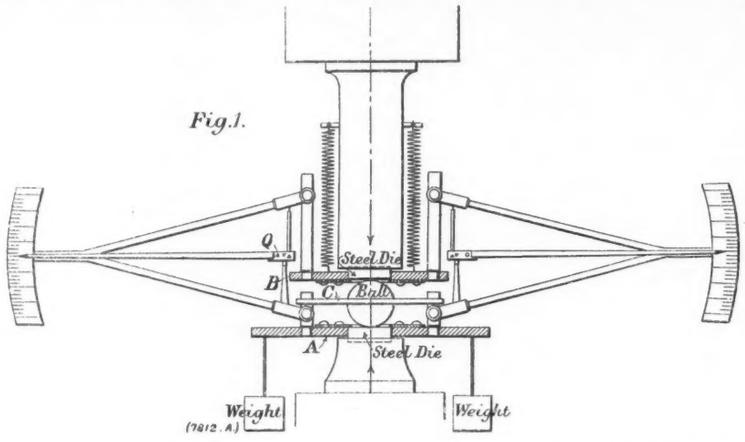
When two elastic parallel plates separated by a sphere are loaded, the plates approach one another owing (i) to the indentation of the plates and (ii) to the distortion of the ball.

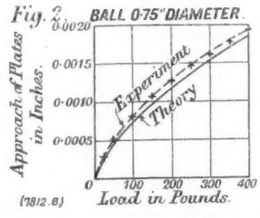
The theory of the stresses and the resulting strains which occur when spheres and plates are loaded in the above-mentioned manner is of a complex character and rests on hypotheses which do not rigidly hold. The commonly accepted theory is due to Hertz and Heerwagen, while Chatley had also advanced a theory which does not differ materially from that just mentioned.

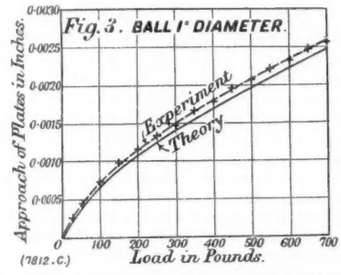
Stribeck measured the elastic compression of steel balls and obtained results agreeing, within narrow limits, with the theory advanced by Hertz (see Engineering, April 12, 1901, page 463). His experiments, however, only covered a range of ball diameters of comparatively small size. In the meantime the loads commonly placed on ball bearings have steadily increased, thus necessitating the use of larger balls. Unfortunately there are practically no data existing as to the load-carrying capacity of large balls. In the absence of data it is often assumed that it varies as the square of the diameter, but there is good reason to doubt the accuracy of the assumption. It is believed that in the hardening process the core of large balls remains comparatively soft, while the shell becomes extremely hard. If this state of affairs actually exists it is reasonable to suppose that large balls will not carry so great a load in proportion as small balls which are hardened throughout to more nearly the same degree of hardness. It was thought that some evidence upon this point might be obtained from a measurement of the strain which balls of different sizes undergo when loaded between flat parallel plates. The writer therefore approached the Board of Scientific and Industrial Research with the object of getting a grant to enable him to investigate this and other matters connected with ball bearings.

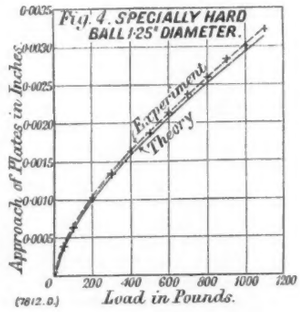
On discussing the matter with ball bearing manufacturers the author was very fortunate in getting the loan of some large balls which are not procurable on the open market. Balls varying from 8 in. diameter downwards were tested between hardened steel plates, and the approach of the plates when under load was carefully measured.

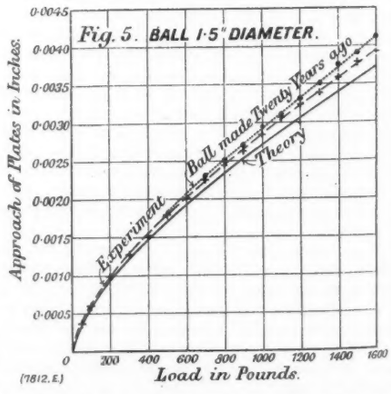
The strains of balls up to 3 in. diameter agreed well with the Hertz theory, except that the index of the power of the load was slightly greater than that indicated by the theory. Balls 4½ in. and 8 in. diameter, however, behaved somewhat differently; under low loads up to roughly one-quarter of the safe working load the strains were greater, and at higher loads than this they were less than the theoretical. No explanation is offered for this peculiarity. It was expected that if the cores of large balls were in a comparatively soft state the proportional strains would have been greater than in the small balls, but as far as these experiments go this is not the case. On account of this unexpected result











the tests were repeated several times, the balls being turned round between each test in order to expose fresh spots to the dies, but within minute limits of error the results were the same in all cases.

In all the balls there was a suspicion of hysteresis, *i.e.*, the loading up curve was not absolutely identical with the unloading curve, but the difference was not sufficiently definite to warrant the statement that hysteresis was apparent, possibly it might have been detected if much more refined measurements had been made.

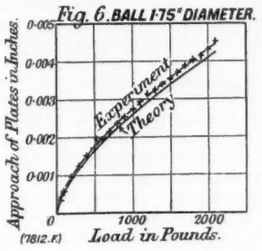
The dies between which the balls were compressed were of hardened steel kindly made and presented by Mr. H. Brearley, of Brown Bayley's Steel Works, Sheffield. Of the first two dies supplied, one was hardened throughout and the other was case-hardened, but no indication was given as to which was which. After a few experiments, however, it was quite evident that one of the dies was too soft, as there was a distinct indentation after testing; the other, however, appeared to be perfect. On inquiry of the above-mentioned firm it turned out that the soft die was the case-hardened one. Further dies hardened throughout were kindly supplied by the above-mentioned makers. The composition of the steel was as follows:—

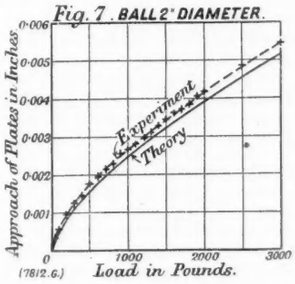
	Per Cent.
Carbon	0·92
Silicon	0·20
Manganese	0·43
Sulphur	0·046
Phosphorus	0·044
Chromium	1·46
Iron (by difference)	96·90

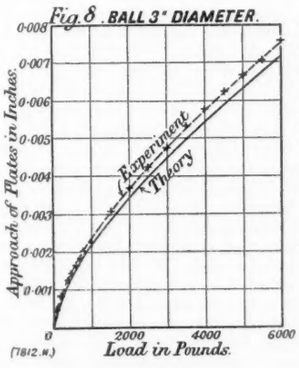
None of these dies showed the slightest sign of indentation, but one die broke when near the maximum load on the 8-in. ball.

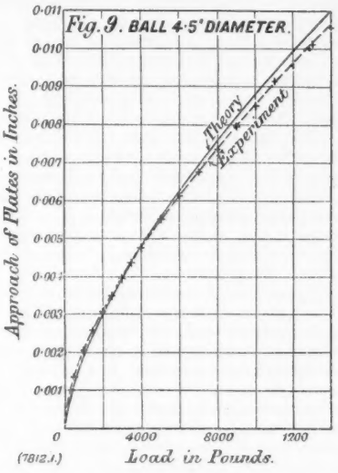
The surface of the dies was carefully ground on plate glass to as perfect a smooth and flat surface as possible, rouge being used for the finishing operation.

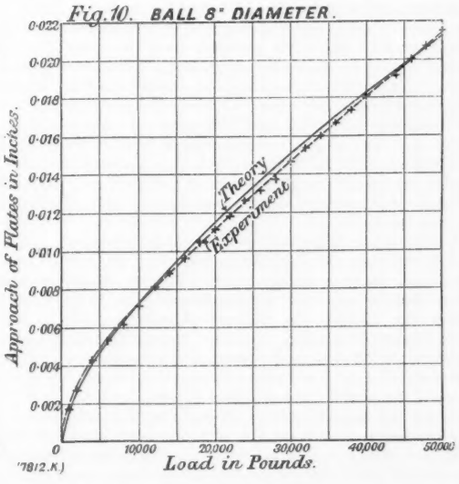
The tests were carried out on a 50,000-lb. Olsen testing machine, which was checked for accuracy by dead weights. It was found that the necessary degree of accuracy could only be obtained if the steelyard of the machine was brought to exactly the same level at each load. A pointer was therefore attached to the extreme end of the steelyard, which was brought to a fixed mark at each change of load. With the ordinary belt drive this was found to be impossible of attainment, a hand wheel was therefore fitted to the driving shaft of the machine and the load was applied by hand. With these refinements the machine behaved quite satisfactorily.











The results of the experiments are recorded in the diagrams Figs. 2 to 10 annexed.

It was intended to measure the approach of the plates by means of two fluid gauges of well-known pattern which were guaranteed to read to one hundred thousandth of an inch, but on testing them it was found that they were seriously in error, and, moreover, the error was not constant at all parts of the scale. Such gauges, when accurately made, are most useful for certain purposes, but this was certainly not one for which they were suitable.

The apparatus was as shown in Fig. 1. The hardened steel dies were held in position by plates A and B provided with lips which bore on the face of the dies, the necessary pressure between the lips and the dies being obtained by weights on the lower die and springs on the upper, as shown. Thus, if the dies themselves shifted or other parts of the apparatus were strained when the load was applied it introduced no error in the measurements.

The approach of the dies was measured by means of two extensometers reading to $\frac{1}{10,000}$th of an inch, the mean of the two readings being taken. In order to get the ball truly central on the dies a light template C was used which fitted the ball and the two upright guides. After a small initial load was placed on the ball the template was lowered clear of the ball. Thus the zero reading on the extensometers did not coincide with zero load on the ball, the initial load, however, was always very small. The calculated approach for this initial load was added to all subsequent readings. Attempts to get zero load readings were made, but the results were irregular probably owing to the minute inequalities on the surfaces of the balls and dies being of relative importance as compared with the approach of the dies under such small initial loads. If there were a minute hill on the ball at the point of contact with the die the approach of the dies would be too great at first. On the other hand if there were a minute flat on the ball at the point of contact the approach of the dies would be too small. If the surfaces of balls are examined under a microscope it will be quite evident that such minute initial discrepancies may be due to this cause.

The commonly-accepted theory of the approach of flat elastic surfaces when separated by an elastic sphere of similar material is as follows:—

Let δ denote the distance, in inches, by which two flat elastic plates, separated by an elastic sphere of similar material, approach one another when subjected to a load of P pounds.

Let d denote the diameter of the ball in inches.

Then taking Young's modulus of elasticity for steel as 30,000,000 lb. per square inch

$$\delta = \frac{1}{32{,}000}\sqrt[3]{\frac{P^2}{d}}$$

$$\delta = \frac{P^{\frac{2}{3}}}{32{,}000\, d^{\frac{1}{3}}}$$

The tests now under consideration show that the above relation does not strictly hold as regards the relation between δ and P.

Let

$$\delta = \frac{P^n}{32{,}000\, d^{\frac{1}{3}}}$$

The following values of n have been found:—

Diameter d In.	n	Remarks.
0·75	0·673	Balls of ordinary commercial quality.
1·00	0·673	Balls of ordinary commercial quality.
1·25	0·671	Specially hard ball.
1·50	0·673	Ball of ordinary commercial quality.
1·75	0·673	,, ,, ,,
2·00	0·674	,, ,, ,,
3·00	0·673	,, ,, ,,
4·5	Above $\frac{2}{3}$ at low loads Below $\frac{2}{3}$ at high loads.	,, ,, ,,
8·0	,,	,, ,, ,,

From the above results it appears that

$$\delta = \frac{P^{0\cdot673}}{32{,}000\, d^{\frac{1}{3}}}$$

for all but very large balls.

The approach of the dies under any given load is therefore somewhat greater than theory would indicate. It appears to vary (except for very large balls) exactly with the theory as regards the diameter.

If the modulus of elasticity differs from that assumed it will alter the constant 32,000, in that case the value of n will also alter. But a mere alteration of this constant will not bring the experimental and theoretical lines into agreement so well as the suggested modification in the value of n.

Inserting the experimental value of $n = 0{\cdot}673$ in Stribeck's equation* for finding the distribution of the load on the balls in a bearing, instead of Hertz's value of $n = \frac{2}{3}$, it only affects the third place of decimals, hence it is of no importance.

The above-mentioned experiments, the results of which are, as stated, illustrated in Figs. 2 to 10, appear to show that the Hertzian theory of the compressibility of elastic spheres agrees very closely with experiment except in the case of very large

* See Goodman on "Roller and Ball Bearings," Proceedings, Institution of Civil Engineers, vol. clxxxix.

balls where there is a small discrepancy possibly due to the lack of homogeneity in the spheres themselves.

The author wishes to express his thanks to the Board of Scientific and Industrial Research for a grant to enable him to get the necessary apparatus and assistance required for making the above-mentioned tests, also to Mr. Brearley for presenting the dies, also to Messrs. Hoffmann and the Skefko Ball Bearing Companies for lending and presenting balls.

NOTE.

Institution of Naval Architects.

The programme of the Summer Meeting in Holland has now been completed. The members will travel by the Folkestone-Flushing route on Saturday, September 1, and will be entertained to dinner by the Reception Committee on arrival at the Bad Hotel, Flushing. Sunday is to be devoted to sightseeing. The opening session for the reading and discussion of papers will be held on Monday morning, under the chairmanship of His Grace the Duke of Northumberland, the President of the Institution. Sir Archibald Denny, Bart., will present a paper on "Notes on the Curves and Formulæ for Regulating the Water-tight Sub-divisions of Passenger Ships," and Mr. A. C. F. Henderson will submit one on "The Sub-division of Large Passenger Steamers," while the third paper will be on the subject of "Dutch River Lighters," and will be read by Mr. A. M. Schippers. After a visit to the Schelde Yard, the party will proceed to Scheveningen, which will be made the headquarters for the remainder of the meeting. Dry docks and shipyards in Amsterdam will be visited on Tuesday. On Wednesday morning, the second group of papers will be discussed. Professor D. Dresden will deal with the question of "Steam Turbines for Marine Propulsion in Holland." In the next paper, Mr. W. J. Muller will give "Practical Experiences with Mechanical Stokers Applied to Marine Water-tube Boilers." Lieut.-Col. F. Modugno will submit a contribution on "Internal-Combustion Engines Exhausting into Low-Pressure Turbines," and Professor G. W. Hovgaard will discuss "The Theory of Bending." The remainder of the week will be devoted to visits to works at Rotterdam, or alternatively to sightseeing, and the party will return to England on Saturday, September 8.

LITERATURE.

The Engineering of Excavation. By George B. Massey, Consulting Engineer, Member Am. Soc. C.E., Vice-President, Randolph-Perkins Company. New York: John Wiley and Sons, Inc.; London, Chapman and Hall, Limited. [Price 30*s.* net.]

The ample expanse of the United States provides opportunity for the construction of canals, railways, aqueducts, irrigation works, &c., on a scale that older nations, occupying smaller territories and hampered by previous constructions that were adapted to, and sufficed for, a limited traffic in days of less production, may envy, but with which they cannot compete. The masses of material required to be moved in constructive works that covered huge distances called for the invention of machinery, neither imagined nor needed in simpler times. American engineering and ingenuity have been fully equal to the continual demand for increased power and greater expedition in digging and dredging with the result that the author confidently asserts that the United States lead the way in the variety and extent of excavating machinery produced, and at the same time operating at the lowest cost per labour unit and per machine unit. The first cost of the machinery is high, but the expenditure is justified by the small total cost per cubic yard of excavation. Mr. Massey speaks with experience and authority, for he has erected these machines in many parts of the world, has adapted them to different kinds of work, and is especially well equipped to explain their merits and possibilities.

The object of the author is mainly to show the development of the revolving shovel and other apparatus, which by accelerating excavation, reduce the cost of construction. He describes the working mechanism with great minuteness, shows what these machines are accomplishing and gives rules and directions for their economical working. The small revolving shovel is seen to be a most useful tool that will find many applications, when intelligently used. Designed originally for digging and loading material of moderate amount into horse-drawn wagons, it is useful in excavating cellars for buildings, making shallow cuts for street gradients, and in loading sand, gravel, and crushed stone from stock piles. The power may be steam, internal combustion engines, or electricity. This last is a comparatively novel introduction that has given great satisfaction. The advantage of this particular form is that it digs all the time. There is no running back to start a new cut, and its movements are controlled by a very few workers, making it a manual labour-saving machine. The shovel works very rapidly, making three or four dips a minute under ordinary conditions. Consequently the wagons are loaded up very rapidly, and generally cannot move out of the way as quickly as they are filled. Hence the horse is being replaced by the automobile truck, which takes up less room, will carry greater weight, and will get away quicker. The lesson conveyed is that expedition does not depend so much on the speed of excavation, as on the ready transport of the dislodged material.

Increase in size and power gives the revolving shovel a wider field of usefulness. It has no rival in stripping the overburden from deposits of iron ore, coal, phosphate, &c., when occurring at a depth of 40 ft. or more below the surface, or at times in mining the material itself. In Minnesota where the hematite is at great depth, the shovels are used to load trains of cars located on the original ground surface, 50 ft. above the ore. In copper mining the standard two-truck shovel has proved of immense advantage, but it is being rapidly supplanted by more powerful machinery, the capacity of whose dipper may be as much as 7 cubic yards, and when working to its full extent will handle six times as much material as the standard shovel. The figures, if adequately grasped, show the great strides the new machinery is making. With the standard shovel, material could be dislodged from the face of the bank up to 33 ft. in height, now the revolving shovel will work 72 ft. above the track, while the width of the cut is increased from 46 ft. to 130 ft. or from 1,518 square feet, to 9,360 square feet of cross section. The deposit of the waste at a greater distance from the working face is also of great advantage.

Coal stripping offers another large field of employment, and in South East Kansas 45 of these huge machines, each weighing, when fully equipped, about 200 tons, are working bituminous coal, 40 ft. below the surface. In working phosphate fields with heavy overburden, it is not unusual for one machine to effect the stripping and followed by another, mining the phosphate, though it is generally more economical for the stripping and mining to be done by the same machine. In canal construction, the revolving shovels are placed in the excavation and load cars placed on either bank. For embankments and level construction, the Tower excavator possesses many advantages, since it will excavate and deposit material at a distance of 500 ft. from the place of working. This removal of material to a convenient distance from the actual digging has made the drag line excavator a very useful adjunct to the steam shovel. The latter is necessarily supplied with a very short and heavy boom, to withstand the strain thrown upon it by forcing the dipper into the bank, but in a drag line machine the boom is long and light, being subject only to the weight of the bucket on it. In the largest sizes, the boom is 155 ft. and carries a 5-yard bucket. The length of the boom does not give the radius of action, however, as it is stepped some distance from the centre of the machine, and is much inclined to the horizontal. But the sweep is considerable and highly useful, when the material excavated can be left where it is deposited.

Much space is given to the description of dredging machines, that work in harbours and estuaries, removing sand and gravel by suction pipes and other known means. In this class may be placed the dipper dredge, which is a form of bucket-ladder dredge, and indeed all forms of excavators which require a hull for the support of the machinery and are movable on water. Various types are fully described and illustrated, and carefully drawn specifications are supplied that will prove valuable guides to practical men. The chapters on hydraulicing and drilling are of great interest, but are hardly likely to find practical application in this country, for we have not the necessary abundance of water working under sufficient head to enable us to utilise the former, and the absence of petroleum removes one great need for drilling. But here, as elsewhere, the information is thorough and practical.

The author has rendered a distinct service by setting out clearly the object which each type of machine serves, and the means by which its end is accomplished. The capabilities of different types of apparatus are contrasted, the staff required for efficient work is indicated, and the amount of work that can be achieved under different conditions accurately estimated. The book should fill a decided want, for the wider use of mechanical appliances in excavating is building up a new industry and demanding greater expert knowledge in its use. An effort is made here to equip thoroughly those who will handle these machines, so that they may be used most economically in the work to which they are applied. The selection of the proper form of machine for particular objects is a delicate task, the modifications which may be needed in the mechanism require great ingenuity, and exact theoretical knowledge is necessary if the lowest operating cost per cubic yard is to be attained.

El Arte de los Metales (*Metallurgy*). Translated from the Spanish of Alvaro Alonzo Barba by Ross E. Douglass and E. P. Mathewson. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, 1923. [Price 17*s.* 6*d.*]

To the writer on science or technique is seldom paid the compliment of reproducing his works after the lapse of two or three centuries. Unlike the speculations of philosophers or the visions of poets, the facts recorded are supposed to be superseded by new researches, or rendered valueless by accumulated experience. The translators of this old-world book have thought differently, and as we hold rightly; the world might very well wish to know how the Spaniards, placed in sudden possession of great mineral wealth, treated the ores and made the gold and silver contents available as bullion. Were the methods wasteful or unintelligent and would the tailing dumps and wastes, scattered through the old mining districts of Bolivia, yield a profitable return, if treated by the exhaustive processes of to-day. Engineers and metallurgists have, we believe, long since answered this question in the negative. The old experts did their work very thoroughly, and have left but little for improved technology to glean, though the means adopted are less certainly known. We know so little of the men who, toiling far from home, with but little reward, gave Spain the treasure of which she made but an indifferent use. The knowledge that the men were capable and did good work though furnished with but little exact knowledge and inadequate appliances, should make us more eager to comprehend the extent of their achievements, and to appreciate how far insight and industry compensated for the want of tools and training.

One of these men, Alvaro Alonso Barba, parish priest of San Bernardo, Potosi, about 1630, has in this work very clearly revealed himself and his methods. He not only penetrated far into the science of metallurgy, but was anxious to place the main industry of Bolivia on a better footing, and wrote this book, the earliest published on American metallurgy, with the view of introducing improved methods. Barba had no teachers and no models for his guidance. The authors he quotes with so much respect and veneration were far his inferiors in all that related to smelting, and the treatment of ores, and when he trusts to the information drawn from such sources, as in his first book giving a summary of the geological knowledge of his time, he grows dull and tedious. But when guided by his own keen observation and ripened experience, he describes the processes used in amalgamating gold and silver ores, or, for the smelting and refining of

metals, he can always hold our attention. In another place, when inveighing against the loss of silver occasioned by imprudent treatment of wastes in refining, he remarks that the smelters of Oruna always threw away certain residues, "until I went there and bought up these wastes or slags for a small sum, and recovered some thousands of pesos in silver therefrom," and then escapes from him what sounds like a sigh of regret, "To-day, however, from my example, they know how to recover everything."

Throughout, practice outstrips theory and successful results are obtained though the theory is often unsatisfactory. It is not difficult to see that the submissive acceptance of an authoritative teaching, unsupported by cautious experiment, explains the want of coherence, while the childlike adherence to the beliefs of the age adds not a little to the interest of the work, as indicating the narrow grooves in which intelligence operated. Here is a man, clear-headed, and confident in his successful manipulation, troubled because he disagrees with some sage, who attributed the mobility of quicksilver to the presence of evil substances in the mixture, and urges that "we should rather attribute it to the lack of the final stage in genesis, which Nature (either from lack of time or for some other reason) could not bestow." In another form, when describing the veins in marble and the forms that molten lead assume when dropped into water, he shows his trustfulness in authoritative teaching, and not a little of his native caution, by introducing a striking example of Nature's caprice with a circumspect "It is said," and goes on to state that "in Constantinople, in a place which is called the House of Wisdom, there is a kind of marble slab of which the veins form an image of John the Baptist, with his shirt of Camel's Hair, so exact that nothing would be wanting to make it complete in its delineations, if only one of the feet were more perfect."

In rendering the work into English, the translators have enjoyed special advantages by reason of familiarity with Spanish methods of mining and smelting, acquired during professional work in South America. Some of the technical words that have puzzled or misled some commentators are easily read by them, since many terms have been preserved with nearly the same orthography. The use of modern terms in translation may be defensible, since the same apparatus, however much varied, is still used, and the same chemical reactions follow from the same processes, but such terms as "silver halides" and "reverberatory furnaces" imply a nomenclature unfamiliar to the author, though he explains perfectly well what he meant.

The book made its appearance in 1640 and was reprinted in 1675 and 1679. The original edition is said to have been banned and burnt by the Inquisition, only three copies escaping, which are now in the British Museum. The translators have used a later edition, that of 1729, which has been rigorously compared with the original copies. They recommend this work, quaint in its style but sound in its methods, to all interested in the history of early Spanish industrial achievements in South America as well as to students in the progress of metallurgy. With this recommendation we would heartily associate ourselves.

Domestic Sanitation and House Drainage. By HENRY C. ADAMS, M.Inst.C.E., F.R.San.I., M.Inst. Water Eng. London: Henry Frowde and Hodder and Stoughton. [Price 10*s.* 6*d.* net.] Oxford Technical Publications.

LIKE many text books of an elementary character, this one owes its origin to a desire to preserve what is valuable and instructive in a series of lectures delivered to students of sanitary science, and as the author is quite aware, the published book must differ widely from the extempore lecture. What we hear once, adroitly arranged to stimulate curiosity, with all the salient points emphasised and all the difficulties toned down or suppressed, would make an unsatisfactory appearance when presented as a printed page, in which every sentence may be weighed and the argument carefully analysed, with the view of extracting every grain of information. The author has therefore diligently revised his lecture notes, and as he tells us, "given particular attention to those parts of the subject which an average student finds it most difficult to grasp in the course of a lecture." Naturally, drains and sanitation figure largely in the treatise, and many of the objects sought to be attained, and the methods to that end might well receive attention from others than professional students, for the national health will improve as the principles that govern sanitary precautions and requirements are understood and adopted.

The author apparently planned his work on wide lines, which subsequently he found desirable to curtail. He opens with a chapter on meteorology, a subject so remote from domestic sanitation that it could be warranted only by the most comprehensive treatment. Moreover, to discuss the cause of rain and to omit all mention of adiabatic cooling is not edifying, and what are we to think of a serious author who could write such a sentence as "temperature reduces 1 deg. F. for every 270 ft. above sea level, because although one gets somewhat nearer to the sun, one is further from the main bulk of the earth." The misfortune is that the childish remark about getting nearer to the sun may prejudice any one against the book, whereas the author on his own ground is sound and worthy of attention.

The main value of the book consists in the many practical hints and the clearness of explanation provided on many small matters, which are not appreciated by the householder, and often not by the builder and so-called expert, who has to supply the remedy for defects. How does a drain trap work, why do these necessary evils become unsealed, how is the trouble to be removed, are questions to which very insufficient answers are usually given. How many houses have the mica flap to a fresh air inlet in proper working order? The information provided here is precise and accurate, and would remove much ignorance or indifference, if the public could be made to apprehend the value of what is so persistently neglected. The full force of many of the ingenious devices arranged to prevent evils and to promote efficient sanitation will never be attained, till the public become educated and appreciative of the beneficial effects such appliances can produce. The book would do much good if it could only reach those who would profit from its contents. Even the many Acts and Regulations intended to enforce the adoption of obvious precautions are not regularly observed by local authorities, particularly in the erection of small property where the need for rigorous observance is greatest.

Some statistics, given to show the marked effect on the public health that has followed the introduction of improved drainage, are too remarkable to be passed over without comment. A feature of great importance is that in times of epidemic the protective influence of water-borne drainage is most marked. In Leicester, it was found that in the typhoid epidemic of 1894, five times as many cases occurred at houses with pail closets as at those drained by water carriage. Newcastle and Birmingham under similar circumstances tell the same tale, though the proportion is not so large. Nottingham furnishes a good instance of what can be done by effective drainage, for it is possible to compare two systems, one in use previous to 1905, and one after 1908 when the improvements had been carried out. Previous to 1905, the number of typhoid fever cases in pail-closet houses was 1 in 120 houses, and after 1908 the number was reduced to 1 in 545 houses. The general improvement in all houses was shown by the reduction of typhoid fever cases in water-closet houses from 1 in 558, to 1 in 1,548 houses. It would be illogical to attribute the whole of the improvement to effective drainage, because the causative factors of many contagious diseases, (and typhoid is among the number) are not known, and consequently a link in the argument is wanting. Many micro-organisms that have been under suspicion have been acquitted on the main charge, but nevertheless the results are startling, and cannot be put aside, however discredited some of the old theories of bacterial infection have grown.

To the arrangements of the contents of the book it might be urged that there is a sense of disproportion. When Mr. Adams has discussed drains and drainage in houses and schools, in stables and cow-sheds, and shown how a completed system may be tested, about which very grievous errors are extant, has stirred up the house refuse and glanced at drainage law, he moves rapidly to the end. The service that brings water to us is of not less importance than the service that carries away the waste material, but like lighting and illumination, on which health and comfort largely depends, the subjects are each dismissed in a single chapter. Warming and ventilation are topics too large to be discussed adequately in the few pages allowed, and are deserving of more consideration in a treatise devoted to domestic sanitation. But the book is one that should be carefully read by those who wish to have healthy surroundings, and are prepared to make some sacrifice to secure the benefits that science and experience offer to the public.

Calculations in Heating and Ventilation. By G. S. COLEMAN, D.Sc., Director of the Department of Municipal and Sanitary Engineering in the College of Technology. Manchester: Longmans, Green and Co., London, 1923. [Price 15*s.* net.]

AMONG the various indications that suggest that pupils of technical colleges are insufficiently prepared for the special instruction it is the function of those institutions to provide, must be included the increasing tendency to preface the technical treatises on some department of engineering with introductory chapters having reference to the main subject. The purpose may be necessary and well intentioned, but it is rarely satisfactory since it fails to provide a sufficient, solid foundation for further research. It is, however, the plan adopted by Dr. Coleman who inserts in this work, seven short chapters on elementary mechanics, and other seven on theoretical physics, with the result that more than one-third of the book is occupied with matter only remotely connected with that indicated by the title. This course is defended on the ground that "most students need some kind of revision in this part of their work, and that it is useful to have some text to which handy reference can be made at once." But the kind and amount of information are such that a boy might well be expected to acquire at school. Youths of the mental calibre and age that frequent, and profit by, these classes, might reasonably be expected to have a good working knowledge of the calculus, and to have mastered a reasonable amount of physics, without in any way specialising, or injuring their literary training. Certainly technical classes would be less overloaded if the teachers were able to adhere more closely to practical work. The author thinks it a merit that no use is made of advanced mathematics, and holds it for a recommendation that the most elementary knowledge of the calculus is introduced in only two instances. We can hardly agree with him, but it indicates the type of student for whom the treatise has been prepared.

The general underlying principles in any science do not alter in a few years, and trade practices change slowly, so that one does not look for originality, and indeed Dr. Coleman expressly states that his object is to avoid novelties, and to give standard solutions of problems that are countenanced by respectable authorities, enlisting these names as evidence of the soundness and reliability of the contents. Some danger, however, is to be apprehended in adhering closely to stereotyped methods that bear the stamp of approval and success. There is little inducement to experiment or advance, and every tendency to accept as final the schemes that are in vogue, or to adhere to established practice. Such a course is the more probable as the results of experiment are in many cases too uncertain to carry conviction. Over and over again the author, after very properly seeking for rigorous theoretical solutions, and showing successfully the proper method of attacking a problem, is compelled to admit that the doubtful character of the constants involved, gives indefiniteness to the conclusion and leaves the final appeal to experience. This vagueness is confirmed by reference to trusted authorities, whose numerical coefficients will show grave discrepancies. The insufficiently trained mind may well be excused, if it sees in this inexactness a reason for following without examination the practical examples which exist. If it be a question of the number of square feet that a radiator must have in order to raise the temperature of the air by a definite amount, there will be a temptation to inquire what is the rule followed in neighbouring property, rather than to appeal to first principles. Or if the question be one of ventilation, wherein the effect of outside

winds can upset the most careful considerations, may he not adopt and be justified in adopting the results of previous practice, rather than struggle with formulæ which are uncertain in their character and may be misleading in their application.

To do the author justice, he has put his points well, and frankly admits the want of decisiveness in his conclusions. Even the amount of inconclusiveness is frequently shown. There is no question about the correctness of the manner of attacking a problem, or of the sufficiency of the method, but the lawless and irregular nature of the variables baffles the most accurate analysis. In detailing the methods in which work is to be carried out, the author is clear and explicit. His systematic arrangement is as good, as his illustrations are simple and to the purpose. The main object of the treatise it must be remembered, is to furnish working examples, and models for examples, that will be instructive to students and a time saving assistance to teachers. Here again Dr. Coleman has succeeded. The examples are a direct outcome of the text which provides sufficient information for their solution, if intelligently used. We submit, however, that there is a possibility that the connection between application and theory will not be adequately recognised in actual practice.

BOOKS RECEIVED.

United States Geological Survey. Mineral Resources of the United States. I: 1. *Cadmium in* 1922. By C. E. Siebenthal and A. Stoll. II: 31. *Petroleum in* 1919–21. By G. B. Richardson. II: 32. *Natural Gas in* 1919–21. By R. S. McBride and E. G. Sievers. Washington: Government Printing Office.

Practical Tests for the Electrical Laboratory. A Textbook for Vocational Schools. By Chesley H. Johnson, and Ralph P. Earle, B.S. London: Constable and Company, Limited. [Price 16*s.* net.]

United States Geological Survey. Bulletin No. 732. *Geology and Ore Deposits of Shoshone County, Idaho.* By J. B. Umpleby and E. L. Jones, Junior. [Price 40 cents.] No. 740. *Mica Deposits in the United States.* By D. B. Sterrett. [Price 50 cents.] No. 741. *The Jarbidge Mining District, Nevada, With a Note on the Charleston District.* By F. C. Schrader. [Price 20 cents.] No. 743. *Geology of the Oatman Gold District Arizona. A Preliminary Report.* By F. L. Ransome. [Price 10 cents.] Washington: Government Printing Office.

United States Geological Survey. Water Supply Papers. No. 488. *The Floods in Central Texas in September,* 1921. By C. E. Elsworth. [Price 15 cents.] No. 493. *Hydro-Electric Power Systems of California and their Extensions into Oregon and Nevada.* By Fredk. H. Fowler. [Price 2 dols. 25 cents.] Washington: Government Printing Office.

The Principal Factors in Freight Train Operating. By Philip Burtt. London: George Allen and Unwin, Limited. [Price 10*s.* 6*d.* net.]

The Lancashire and Cheshire Coal Research Association. Bulletin No. XIII. *The Determination of Carbon Monoxide in Vitiated Air, including the Analysis of Mine Gases.* By F. Sinnatt, M.Sc. and L. Slater, Ph.D. [Price 2*s.* net.] No. XIV. *Transparent Preparations of Coal for Microscopical Investigations.* By J. Lomax, F.G.S., and J. R. Lomax. [Price 2*s.* net.] London: H. F. and G. Witherby.

Les Méthodes Modernes D'Organisation Industrielle. By L. Benoit. Paris: Gauthier-Villars and Cie. [Price 18 francs.]

Carènes de Formes Nuisibles, ou Favorables à leurs grandes Vitesses; et Résistances de L'Eau à leur Translation. By M. le Vice-Amiral F. E. Fournier. Paris: Gauthier-Villars and Cie. [Price 3 frs. 50.]

Die Pumpen. By H. Matthiessen and E. Fuchslocher. Berlin: Julius Springer. [Price 1*s.* 8*d.*]

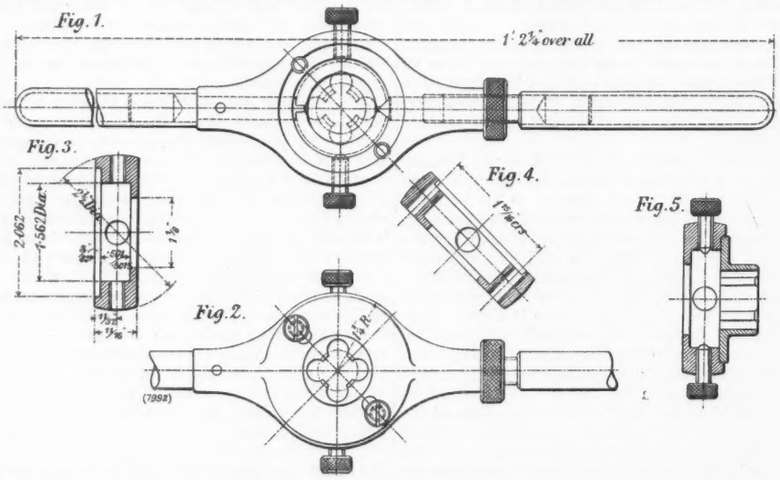
Winter Work for the Unemployed.—A letter from the Ministry of Health to the Barrow Guardians states that by means of grants it may be possible to secure the placing of important orders in towns where heavy engineering is the principal employment. It adds that the Government has given authority to the Admiralty to anticipate future requirements to the extent of 500,000*l.*

Leeds Technical School.—A pamphlet has been issued by this school giving particulars of the day courses in mechanical and electrical engineering for the session 1923–1924. The courses include workshop practice and theoretical training; the illustrations of the turning, milling, fitting and other shops, and of the physical laboratory, show them to be well equipped with the necessary machinery and apparatus.

French Foundry Exhibition and Congress.—The Association Technique de Fonderie, whose address is 15, Rue Bleue, Paris 9, announces that a Foundry Exhibition and International Congress are to be held in Paris, in September next, at the Ecole Nationale d'Arts et Métiers, 151, Boulevard de l'Hôpital. The exhibition will be open from September 2 till 16, and the congress will be held from September 12 till 15.

ADJUSTABLE DIE STOCK.

CONSTRUCTED BY THE BIRMINGHAM SMALL ARMS CO., LTD., ENGINEERS, BIRMINGHAM.



We illustrate above an adjustable die stock recently introduced by the B.S.A. Tools Company, Limited, Sparkbrook, Birmingham, in which the means of adjustment form a permanent part of the tool, an arrangement which will be highly appreciated by all who have to produce screw threads by hand.

As indicated in our engravings, Figs. 1 to 5, one of the stock handles is provided with a screw thread and lock nut, and terminates in a 90 deg. hardened cone. By twisting this handle the cone can be forced into a conical groove at the joint of the two dies, thus increasing the cutting diameter of the die. Having thus secured the size desired, the two dies are next centred and locked by the thumbscrews shown. The threaded handle is provided with a locknut to prevent it slipping back when in use. To reduce the cutting diameter the cone is slacked back, and the dies locked and centred again by tightening up the thumbscrews already mentioned.

The dies are retained in position by the guide shown, which is held in place by two retaining screws. On slackening these the guide can be rotated till the slots provided in it come opposite the retaining screws. It can then be removed, and this done, the dies are easily pushed out of the recess into which they fit.

The range of adjustment provided is large, and the die being in two pieces cannot be split by over adjustment, whilst as it is unweakened by screwholes it is both light and strong. Ample clearance is provided for the swarf. Two sizes of the die are stocked, one to take dies up to 1¼ in. in diameter and the other for 2 in. dies. The set of dies for the smaller stock will cut from ¼ in. up to ½ in., increasing by sixteenths; whilst the larger stock is provided with seven dies cutting from ¼ in. up to ¾ in., the threads being either the B.S.W. or B.S.A. type.

PORTABLE CHRONOSCOPE TIMING APPARATUS.

To the Editor of Engineering.

Sir,—After reading the article dealing with the portable chronoscope, on page 217, of your issue of 17th inst., it would appear that Messrs. The Low Engineering Company were responsible for the design of the apparatus, and that it was specially constructed for them by Messrs. Tinsley. As a matter of fact, both the chronoscope and the special tuning fork were designed and originated by Dr. A. B. Wood and myself, both of the Admiralty Laboratory, Teddington.

The apparatus shown is a simplified form of a high-speed chronometer developed by us for special purposes and Messrs. Tinsley, having been granted manufacturing rights under our patents, have supplied several sets during the past year, including this one for The Low Engineering Company. I should appreciate it if you would be good enough to insert this letter in your next issue in order that the situation may be made clear.

Yours faithfully,
Joseph M. Ford.

Admiralty Research Laboratory, Teddington, Middlesex, August 20, 1923.

DANGEROUS VOLTAGES.

To the Editor of Engineering.

Sir,—In your issue of August 10, page 180, column 2, it is stated "Alternating current at 250 volts seems to be distinctly more dangerous than direct current of the same nominal voltage." As the maximum voltage for alternating current nominal 250 is 353 approximate, there is every reason why alternating current should be more dangerous than its equivalent direct current.

I believe there is a case on record where a person was killed at 60 volts, and certainly under certain conditions direct current at 50 volts is nasty.

Some little while ago, when assisting a ship's engineer to wire a battery charging board it was found impossible to handle "live" wires at 50 volts, while one stood on the iron deck. On standing on a piece of wood on deck one felt nothing.

It is not sufficiently realised that voltages which are quite safe, if one's skin is dry and one is standing on a dry wooden floor, may be dangerous if one's hands are wet with perspiration and one is standing on a conducting deck.

It is possible that a very much lower voltage than 60 would be fatal if the skin is broken.

Maximum voltage for maximum voltage direct current should be more dangerous in every case, since only for a fraction of the time of application would an alternating current voltage have its maximum value. Moreover, as the frequency increases alternating current tends to become harmless, self-induction preventing the current penetrating the conductor.

Yours faithfully,
J. L. R. P.

The Parsonage, Stornoway. August 14.

Light and Extra-Light Alloys: Errata.—In our article on this subject published on page 172 of our issue of August 10, there are, we regret to say, two misprints, namely:—in the first column, paragraph six—

$$\frac{\Omega}{\Omega^1} = \sigma^2 \text{ should read } \frac{\Omega^1}{\Omega} = \sigma^2;$$

and in the same column, in formula (3)—

$$\delta^5 \geqq \epsilon^5 \text{ should read } \delta^5 \geqq \epsilon^2.$$

Standard Shafts for Marine Engines.—It will be remembered that about two years ago the British Marine Engineering Design and Construction Committee formulated and published an approved set of standard conditions for the design and construction of marine boilers and shafting. These excellent recommendations met with such widespread approval that this step was shortly followed by another partaking more of an official nature. The Board of Trade called a conference of the registration societies, and as a result a set of rules relating to marine boilers was framed following closely upon the lines laid down by the Committee. These rules were published in 1920. A subsequent conference considered the question of shafting, and an official set of standard conditions and rules has now been issued by the Board of Trade relating to this subject. These rules are obtainable from H.M. Stationery Office, Kingsway, W.C., at the modest figure of 1*d.* net. The rules follow very closely upon those originally formulated by the Committee. Section I of the pamphlet relates to materials, and adopts the British Engineering Standard Specifications and test pieces. Section II relates to the diameters of shafts. Here the subsection dealing with shafts for turbine driven vessels is the same as in the original, save for a slight paraphrasing. In the subsection for reciprocating engines the same formula is adopted and practically the same wording, but a somewhat larger coefficient f, values of which are given in a table. The section on tail shafts follows the substance of the original slightly condensed, but does not deal with outboard and other intermediate shafts. The section on fittings and details presents the greatest divergence from the original in the subsection devoted to bronze liners on shaft, para. 1; the remainder follows closely upon the lines of the Committee, who may thus be complimented upon first formulating provisions which have now been accorded official recognition.

DISC LOADING TYPE OF AUTOMATIC GRINDING MACHINE.

CONSTRUCTED BY THE BLANCHARD MACHINE COMPANY, CAMBRIDGE, MASS., U.S.A.

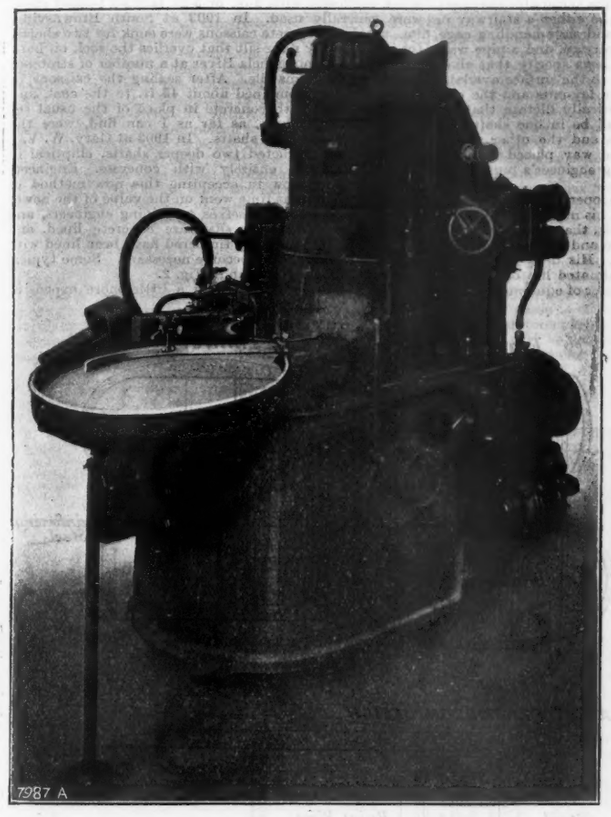


FIG. 1.

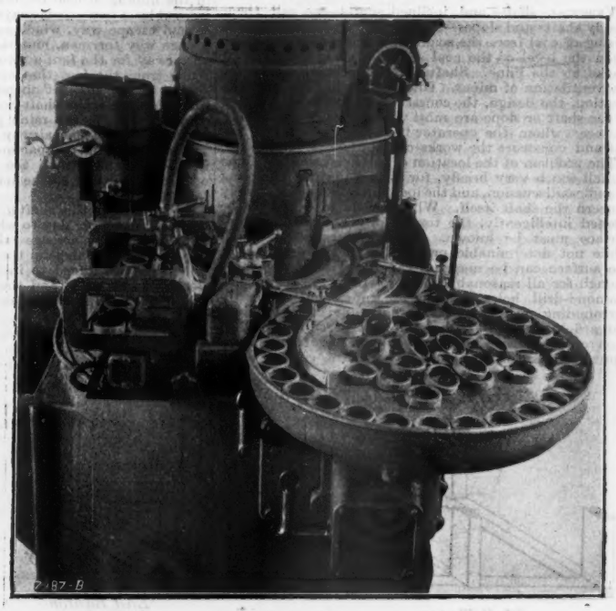


FIG. 2.

THE successful work accomplished with the automatic grinding machine, introduced some time ago by the Blanchard Machine Company, of Cambridge, Mass., U.S.A., has encouraged that organisation to design and place upon the market a modified form for the grinding of rings, washers and similar circular work. This machine is shown in the accompanying illustrations, of which Fig. 1 gives an idea of the appearance and design of the grinder, while in Fig. 2 the disc loading device is seen in use. The path of the work through the machine and its emergence from the demagnetising coil are also clearly indicated.

The base takes the form of a heavy cast tank having a capacity of 180 gallons and is used for the storage of the cooling water for the grinding operations. Upon this bed are erected the revolving feed table and its gears, the revolving magnetic chuck and the structure in which the grinding wheel is suspended. The articles to be machined are dumped near the centre of the nearest revolving system shown, which is the disc loading device. The speed of this table is slightly higher than that used for the chuck. As the pieces are forced outward by the action of centrifugal force they take their positions in a continuous stream which is directed through guides to the chuck. Once a charge of pieces is placed on the table the feeding proceeds quite automatically, and the operator is left free for a period to enable him to handle the containers of the incoming and finished pieces. Before the pieces leave the revolving disc they are directed between guides supported on short arms from the fixed structure of the machine. As the material passes on, it is led on to the chuck, which in the loading position is quite non-magnetic. Just before the waterguards, encircling the grinding wheel, are reached the clutch is energised and the pieces are gripped in place, carried under the guards and conducted below the grinding wheel. Four chuck speeds are available. In one passage through the machine the work is completed to size. The adjustments of the wheel-head, to compensate for the wear taking place during the continued grinding operations, are automatic and operated through the installation of wheel control calipers. The work is thus continuous, and many thousands of pieces can be passed through without any interruption. Once the work leaves the wheel control calipers the section of the chuck it is on becomes non-magnetic, and the finished product is passed out through a demagnetising coil into the containers put in place for its reception. A washing machine may be added on the discharge side of the plant, when it is thought to be necessary. The machine was designed to maintain the size of the finished articles to within limits of plus or minus five ten-thousandths of an inch, and will produce them parallel to within three ten-thousandths of an inch.

As an example of the use of this machine and the results attained it may be stated that in the work of finish grinding ball race rings of $3\frac{5}{32}$ in. diam. and made of hardened steel, one-hundredth of an inch was removed from each of the two sides at the rate of 630 pieces per hour. In rough grinding two-hundredths of an inch from both sides of rings of high carbon steel of $2\frac{7}{8}$ in. diam., 650 were dealt with in an hour. With thrust washers of carburised steel of $2\frac{3}{8}$ in. outside and $1\frac{9}{16}$ in. inside diameters, thirteen-thousandths of an inch were removed from each side in finish grinding at the rate of 550 pieces an hour. In each case appreciable reductions in the costs of machining were shown when compared with the processes formerly in use.

INTERNATIONAL REGULATIONS FOR LOAD-LINES, DECK CARGOES AND SAFETY OF LIFE:—ADDENDUM.—In the third column of page 218, in our issue of last week, the three sentences numbered (1), (2) and (3) appearing immediately before the table should be read as footnotes referring to the numbered sentences in the preceding paragraph.

GERMAN PENETRATION IN SWITZERLAND.—According to the Paris journal L'Industrie Electrique, Swiss periodicals are perturbed at the extent to which German concerns are entering the Swiss market. Numerous companies backed by German funds are being established in Switzerland. The Swiss laws specify that the Board of Establishments working in the country must consist mainly of members of Swiss nationality, but the Germans avoid the difficulty by appointing in addition to the German directors a number of Swiss, who are directors in name only. This systematic penetration is particularly noticeable in the field of electrotechnics. The movement commenced before the war. The Swiss Federal Council has taken means to prevent camouflage in the matter, but, according to our French contemporary, this will not have the desired effect, and German penetration is likely to continue until complete absorption is reached.

SHROUDED PROPELLER FOR THE SALVAGE STEAMER "RINGDOVE'S AID."

WE illustrate below a shrouded propeller fitted to the salvage steamer Ringdove's Aid by the Gill Propeller Company of 17, Victoria-street, S.W.1. The propeller in question has been evolved as the result of an extended series of experiments on smaller craft fitted with propellers of the same type, ranging from 6 in. up to 6 ft. in diameter. The propeller illustrated is 10 ft. 6 in. in diameter and 10 ft. 9 in. mean pitch. The shrouding, it will be seen, tapers in a fore and aft direction with the object of contracting the waterway

through the propeller in proportion to the axial speed acquired by the fluid. The Ringdove's Aid belongs to the Falmouth Docks and Engineering Company and is a composite built naval sloop, 167 ft. long by 32 ft. beam, almost identical with the Greyhound on which William Froude made his famous experiments. Based on Froude's results it was estimated that with a mean draught of 13 ft., some 1,200 h.p. would be required for a speed of 11 knots, using an ordinary four-bladed propeller running at 120 r.p.m. With the propeller shown in our illustration the makers state that a speed of 11 knots was attained with 960 h.p., the speed of rotation being 103 r.p.m. The engines of the Ringdove's Aid have cylinders $22\frac{1}{2}$ in. and 48 in. in diameter by 30-in. stroke, and are supplied with steam at 155 lb. per square inch by two single-ended Scotch boilers fitted with Howden's forced draught.

THE NEW FINNISH ICEBREAKER.—Wide differences were shown in the tenders for the building of an icebreaking steamer of 7,500 h.p. for the Finnish Government. They ranged from 20,200,000 to 35,500,000 Finnish marks. The lowest tender was German, while the highest was that of the Finnish builders.

PRESENT PRACTICE IN THE DESIGN AND SINKING OF MINE SHAFTS.*

By R. G. Johnson, Pittsburgh.

Vertical shafts and inclined shafts—we call them simply shafts and slopes—are necessary openings for the raising of coal from the seams to tipples on the surface when the level of the coal seam is below the railroad tracks at the mine. Shafts are equally necessary for the ventilation of mines. One can readily see that the location, the design, the construction and the equipping of the shaft or slope are most vital duties of the mining engineer whom the operator has commissioned to lay out and construct the works of the mine.

The problem of the location of the hoist shaft or slope I shall touch very briefly, for it is a matter admitting of endless discussion, and the location does not intimately concern the shaft itself. When a field of coal is to be opened intelligently, the topography of both coal and surface must be known. The contours of the coal, while not determinable practically to the degree that the surface can be mapped, can be plotted accurately enough for all reasonable purposes from the sections of diamond-drill holes and other known elevations in surrounding mines. It is strongly advisable to block out a field in 3,000-ft. or 4,000-ft. squares and drill at each corner with a diamond-drill, rather than with a churn-drill, for with a diamond-drill the core is saved and the depth and structure of the coal and its roof and bottom measures are definitely determined.

With the topography of the coal known, the location of the hoist shaft can then be determined. The shaft is merely the connecting link between the most available, economical concentrating point for the mine cars of coal from the mine with the most economical point to load into coal cars on the surface. Seldom does it happen that the most available spot for plant construction with its railroad sidings, power buildings and near-by town sites comes directly over the top of the best shaft bottom location, a point to which the mine loads can be moved with least power and time, and the empties returned to the working places likewise with the least expense. Engineering studies must be made and top costs balanced with underground savings, or top savings balanced with underground costs, to determine the shaft location.

With the location determined, selection of the scheme of bringing the coal to the tipple must be made; that is if the coal is reasonably shallow, whether a shaft is the more economical and desirable or whether a slope is to be installed. This is a big subject in itself, and its discussion hardly comes within our province to-night. I may say, however, that fifteen years ago, if the coal was under 100 ft. in depth, the leaning of opinion was toward a slope, with chain or straight trip haulage. To-day with the successful operation of rubber-belt and steel-apron conveyors in slopes, many prefer a slope for coal up to 200 ft. in depth. Balanced self-dumping cages for shafts still remain the most generally used, and are withal the cheapest means of bringing coal to the tipple in cars. If the breakage of the coal is of no importance and large tonnage is desired from a long-lived field, the use of skips for hoisting is figured by many to prove the best investment. If the coal is deep, skips can hoist more cheaply than cages, for greater quantities can be carried for practically the same bottom cost.

Let us assume that we are to open a field of coal that will last forty years, the depth requiring shafts 300 ft. deep; and, by discussion of the various types with their details, design the shafts and then proceed with the sinking according to specifications fitted to our design. The location is determined and we are to use self-dumping cages. For best handling the many operations necessary in the mining of coal in this section a shaft mine must have at least two passageways to the surface for the cages, a man escape way, which may be either a stairway or a cage way for men, material, and slate-handling cage, an airway for the fan, a return airway, and a pipe way. Aside from the fact that state laws specify that there should be two distinct openings to the surface available for every mine, the shaft-bottom lay-outs and the plan of air-courses in the mine practically dictate that the escape-way and one airway shall be in one shaft, and the coal-hoisting compartments and the other airway in another shaft, with the pipe way placed in either opening according to the mining engineer's pump-room lay-out.

In designing the shafts, the operator decides on a certain output per day to which his mine will ultimately develop. On his acreage—that is, the value of his holding—will largely depend the size and character of plant which he can afford to install. His daily output will determine the size, and the estimated life of the mine will determine largely the character of equipment.

*Paper read before the Engineers' Society of Western Pennsylvania.

Fig. 1. TYPICAL TIMBER SET.

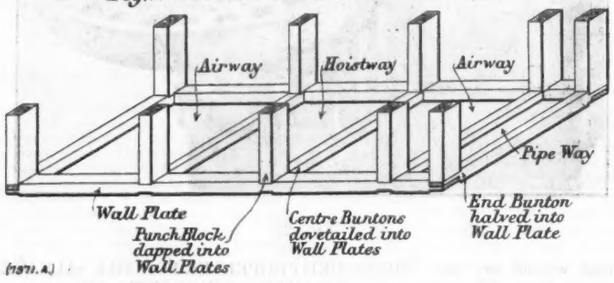


Fig. 2. TYPES OF CONCRETE LINING.

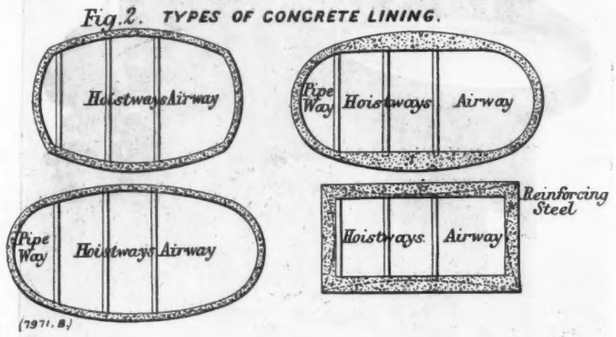
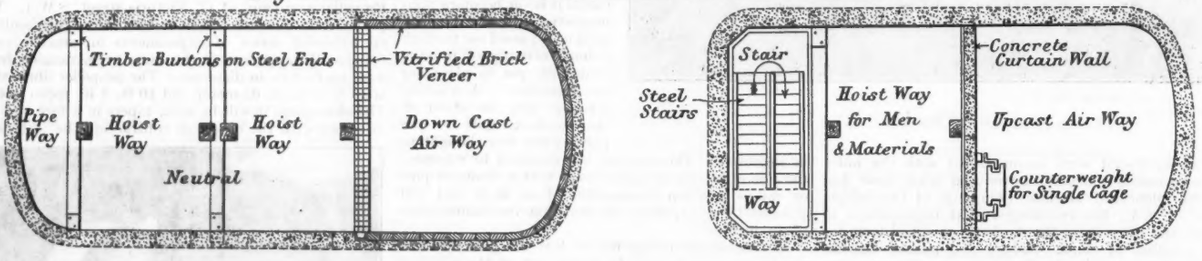


Fig. 3. PLANS OF SHAFTS EMBODYING LATEST PRACTICE IN DESIGN.



With the space required for the cages fixed, the other necessary requirements are area for the ventilating air of the mine, unless the shaft is part of a system of three or more and is neutral regarding ventilation, and area for wires and pipes. At this point in the design the character of the lining must be fixed, for all shafts require a lining to protect the earth or rock sides from falling, and as walls to hold the ends of the buntons which support the cage guides. The character of the lining chosen practically decides many other details.

Until 1903 most of the shafts for the coal mines in this country were timber lined (see Fig. 1). In the Middle West the timber linings were usually "skin to skin"; that is, the rings or sets of timber were placed one directly on top of the other and fastened together with drift bolts. This is an effective means of protection in soft, running and shaly ground, and most of the older shafts in Ohio and Indiana were put down with "skin timber" linings, while in Pennsylvania and West Virginia framed timber sets spaced four or five feet apart vertically with 2-in. or 3-in. lagging behind them were generally used. In 1903 at South Brownsville, Pa., a pair of concrete caissons were sunk for two shafts, for it is largely river silt that overlies the rock on both sides of the Monongahela River at a number of stretches just above Brownsville. After sealing the caissons in the rock, there remained about 45 ft. to the coal, and this was lined with concrete in place of the usual set timber lining. These, as far as I can find, were the first all-concrete lined shafts. In 1903 at Gary, W. Va., there were constructed two deeper shafts, elliptical in shape and lined entirely with concrete. Engineers generally were slow in accepting this new method of lining shafts, but as time went on the value of the newer designs impressed themselves on mining engineers, and to-day most of the new shaft are concrete lined, and many that were formerly timbered have been lined with concrete when relining became necessary. Some typical concrete linings are shown in Fig. 2.

Concrete lining is generally a little more expensive than timber lining, but under most conditions it is permanent. There are sections of the country where strata through which the shaft is sunk provide sufficient sand and rock for concrete purposes and, with the present high price of timber, concrete lining can be done about as cheaply as timber lining. Concrete lining generally provides a dryer shaft, for much of the water that comes from the ribs can be plugged or grouted; this I shall discuss briefly later.

While concrete provides a stronger lining, standard 8 by 10 timbers on 5-foot centres with 2-in. lagging provide a lining amply stout, and with water rings which are catch-basins around the shaft just behind the lining, and proper draining, a timbered shaft can be made as dry as a concrete shaft. The question really resolves itself into a comparison of first costs and ultimate costs. The life of a first-class lining of white oak or long-leaf yellow pine, if the shaft is dry, will run from 12 years to to 20 years. If the shaft is wet, with water constantly dripping over the timbers, its life with minor repairs is almost unlimited. If the field of coal is a small one with a life of twenty years or less, timbered shafts in most sections of the country are cheaper, for the moisture that is found soaking into the timbers in most timbered shafts in this section of the country provides a good fire protection and acts very effectively as a wood preservative. Only in exceptionally dry shafts is a timber lining dangerous. Timber linings in new shafts are not permitted by the state laws of Illinois because of the fire risk. The timbers in some of the later installations have been treated with wood preservatives, but this is not advisable, for it would prove a splendid fuel for a fire.

While I believe the fire risk is small, nothing should be left undone that will remove any risk to life, and this thought always uppermost in the minds of mining engineers to-day generally decides in favour of the concrete shaft.

But after twenty years of watching the developments in the design and construction of concrete-lined shafts, I am not sure they are entirely satisfactory. A large number of the downcast shafts which are lined with

concrete are pock-marked. The lining is slowly scaling and disintegrating. Moisture or rain or dripping shaft water is sucked down with the incoming air and, of course, wets the surface of the lining. The concrete naturally absorbs some water and alternation of freezing and thawing eats into the lining, causing it to peel scale by scale. I am convinced that we must find a suitable waterproofing for downcast concrete-lined shafts, or we shall have to provide a veneer of some impervious nature. I believe vitrified brick would make a very effective veneer, the brick to be laid in cement and locked every four or five courses to the concrete lining with a row of headers (see Fig. 3). Of course, in constructing a plain concrete lining, it is possible with very careful puddling while the concrete is being placed to remove most of the small air bubbles, and in some linings water-proofing compounds have been used; but the success of these waterproofings has been rather indifferent. This trouble with linings to-day is the most serious problem in good shaft construction, closely akin as it is to the handling of the water through the lining.

A treatment of a lining for a shaft in this section scaled and pock-marked by the action of water and ice has been proposed by a New York waterproofing concern, and the work, which I understand will start this spring, will certainly be watched with interest.

In England, France and Germany brick is used for most of the deep shafts that are masonry lined, but engineers in this country have never strongly inclined toward either brick or concrete block. In a flat-sided shaft, brick or block do not give the desired strength in soft strata. Concrete fulfils all requirements of strength and will stand the unusually severe strains produced by the blasting necessary in the sinking process.

Pipes, drains and bunton guide connections can be placed in the lining as it is being constructed. The concrete should be mixed in the proportion of 1 : 2 : 4. It should be from 12 in. to 18 in. thick. Provision is always made, however, that points of solid rock may project within 4 in. or 6 in. of the concrete form. This unquestionably adds to the support of the lining in the shaft.

Concrete, then, will be the medium for the lining of the shafts we are designing, using a vitrified veneer for the downcast compartment, which will be separated from the hoistways by vitrified-brick walls laid in panels on the buntons.

The function of the buntons in a concrete shaft is principally to hold the guides in position. They are seldom figured to support or brace the lining except in the earth surface. This does not conform to the ideas of some, but experience has surely proved that the rock measures have no lateral movement when they are practically horizontal. Use has been made of many different sections of buntons of timber, steel and combination steel and concrete. With timber set lining the bunton is a necessary part of the framework. Timber buntons and steel buntons have resilience to absorb and dissipate the strain imparted to them through the guides by a fast moving cage or skip, but the only reinforced concrete buntons I have ever since were full of small cracks caused, I assume, by vibration. The steel H-beam makes an ideal bunton for a concrete shaft. It should be placed on edge and the top concavity filled with concrete to prevent water from settling therein, but the steel bunton is not readily replaced in case of a wreck of the shaft, and many in the last few years have either used the timber bunton concreted in place or set in niches left in the lining; or a timber bunton which is bolted to short sections of I-beam or inverted channel concreted in. The various types are shown in Fig. 4. The principal objection to steel is its susceptibility to corrosion in the combination of mine air and mine-water drippings, and, while it can easily be painted outside the shaft, nothing entirely effective can be done in the shaft on account of the dampness. The best paint for mine buntons is the home-made mixture of coal tar, Portland cement and kerosene applied hot to the clean steel. I know of one case where the buntons were painted with this combination ten years ago and recent investigation showed the buntons to be in fine condition. Many believe steel buntons are best but, because they cannot be quickly replaced since they are concreted in, a large number incline toward the timber bunton bolted to short steel I-beams concreted in the lining. Where a masonry partition wall is built in the shaft steel buntons are, of course, best.

Guides for the cages are practically always of timber, a prime grade of long-leaf yellow pine being the most desirable. Steel has been tried, but I know of no successful safety device that will work on steel guides to guard the cage from falling in case of accident. Set accurately to plumb-line and gauge, the guides are dapped over the buntons and bolted to them. There are several schemes of splicing the guides, and the simplest and best of these is undoubtedly the butt splice. All bolts are countersunk into the guides, and the heads of the bolts should be set in at least a quarter of an inch deeper than the face of the guides (see Fig. 5).

Fig. 4. TYPES OF BUNTONS.

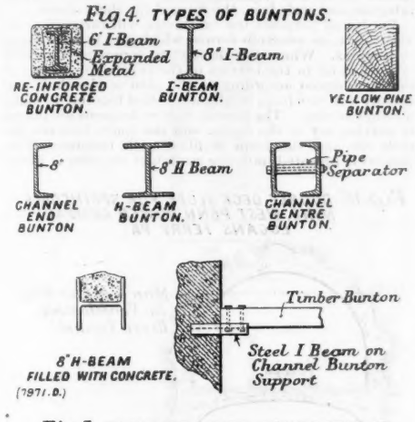


Fig. 5. TYPES OF GUIDE CONNECTIONS.

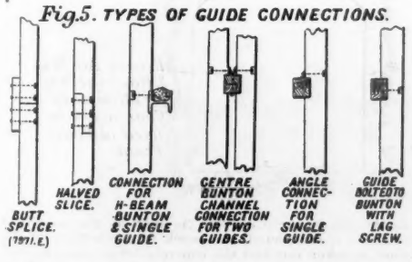

BUTT SPLICE.
(7971. E.)
HALVED SLICE.
CONNECTION FOR H-BEAM BUNTON & SINGLE GUIDE.
CENTRE BUNTON CHANNEL CONNECTION FOR TWO GUIDES.
ANGLE CONNEC-TION FOR SINGLE GUIDE.
GUIDE BOLTED TO BUNTON WITH LAG SCREW.

Fig. 6. TYPICAL CURTAIN-WALL SECTION OF CONCRETE IN PANELS ON STEEL BUNTONS WITH GUIDE CONNECTIONS.

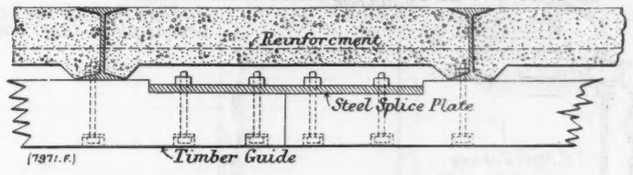
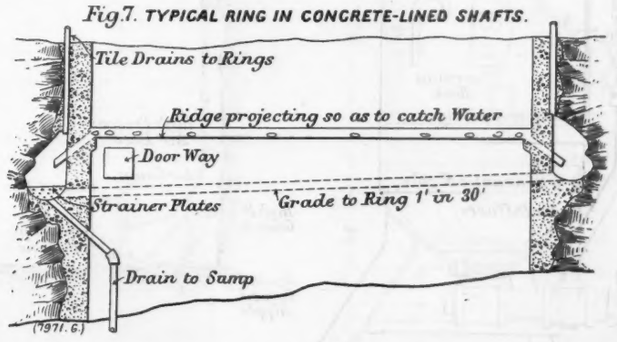


Fig. 7. TYPICAL RING IN CONCRETE-LINED SHAFTS.



Partitions in timbered shafts are of yellow-pine tongued-and-grooved-sheeting either of two layers of 1-in. tongued-and-grooved material spiked with loose joints to the buntons, or of one layer of 1¼-in. tongued-and-grooved sheeting. Partition walls, or curtain walls as they are often called, in concrete-lined shafts are nearly always of reinforced concrete, and while some have been constructed as a continuous solid concrete wall from top to bottom, a thinner and stronger wall can be constructed on steel buntons placed at intervals of 5 ft. or 6 ft. in the shaft. The walls are usually reinforced, and a typical design is shown in Fig. 6, but some of the concrete walls in down cast shafts have peeled and are constantly scaling. I believe they, too, should be made of vitrified brick. The light reinforcement that is now used in concrete walls can be used just as well in the brick wall. Laid in cement mortar with thin joints, they should serve their purpose well. I favour vitrified brick simply because it is the best medium that I know which presents an impervious face. If we can find a waterproof paint that can be applied so that it will be absorbed into the pores of the face of the concrete, or a waterproof plaster that will cling to the lining and will stand the test of time in its resistance to the water, our problem is solved and concrete so treated will be ideal.

The handling of water which is encountered in the sinking depends largely upon the amount of water and the nature of the rock. Grouting is the only method of preventing the water from coming into the shaft, and to-day provision for the sealing of water by injecting cement into the fissures of the water-bearing strata is a part of all specifications. To-day, all prices in contracts for sinking shafts are based on the assumption that if water is encountered grouting will be started and paid for according to provisions in the contract. Usually grouting is paid for per barrel of cement injected, but it would seem that a method fairer to both parties would be an agreement to pay for the cost of grouting on a basis of cost plus a fee per barrel, the fee to include the use of the contractor's plant, and his profit. The grouting clause and its price to-day takes the place of the water clause in the contracts of twelve and fifteen years ago. This clause in former contracts provided for additional prices per vertical foot sunk in case certain quantities of water were struck, the prices to increase as the quantity increased, but this was an inequitable manner of paying for the cost. On one job I saw the contractor lose everything he had because he could not get below the water, the rock being blocky and full of fissures, so that he could make no footage at all in sinking and consequently could earn no premium to pay for the cost of his constant pumping. On another job a contractor was able to construct a water ring just below the water stratum, which was reasonably close to the top of the shaft, and placing his pumping plant at this ring he pumped on, the pumping having no effect on his sinking, which was practically dry. According to the water clause, he was paid, of course, by the foot sunk, for the additional water, and he sunk well and his coffers were filled with gold and there was great joy in the house of the contractor. The fairest water clause for pumping is the one based on paying by the million-foot-gallons for all water pumped. This form of water clause (in addition to the clause for grouting) was used in the contracts for the shafts and tunnels for the Catskill aqueduct which was completed several years ago. A typical water ring is shown in Fig. 7.

In grouting, cement mixed with water to the consistency of cream is forced into the crevices under high pressure through drill holes in the rock, or pipes through the lining. The process was used first in shaft sinking in this country about 1910 on the construction of the Catskill aqueduct, although in Germany and in Northern France the principle was used several years before in cementing around the outside of the shaft before sinking was started.

In 1912 the first shaft of the coal fields was grouted. I recall very well my talk at that time with the chief engineer of the Pittsburgh Coal Company, when with boundless (and later I have thought brainless) enthusiasm I guaranteed in the name of the company with which I was connected to seal off 90 per cent. of all water encountered in the sinking of a timbered shaft which we were to construct. The job was done and the water was shut off, but that experience (with many since) while demonstrating to mining men that it was the best known means for attacking the water problem in the sinking of shafts has shown that there are many difficult angles to the grouting game and that it is not always possible to seal off all water. The larger the crevice and the greater the flow, the easier it is to seal the crevice. The fundamental requirement to grouting is resistance. You cannot grout a length of 2-in. pipe open at both ends, but plug one end and you can pack it full of grout under pressure, and it will be solid and very dense.

If the ground 4 ft. or 5 ft. above the stratum is solid, the grouting can be done very easily. If the strata above the water-bearing seam are full of crevices, naturally or through shattering, these cracks will allow the grout to work out because there is not enough resistance to the pressure of the grout. Such a condition will often take care of itself by the gradual setting of the thin layers of cement in the cracks, and the forcing in of additional cement at low pressure on successive days. Often oatmeal, bran, or dry sawdust is forced in with the cement and settling in the water seals the cracks. If the cracks in the bottom of the shaft cannot be sealed in this manner, it is necessary to put a concrete mattress over the shaft bottom to provide resistance. This scheme while expensive, has always been successful. The grout is usually mixed by compressed air in a grouting tank, as in Fig. 8, and forced into the crevices by turning the pressure of air in at the top of the tank; or the grout may be forced into the crevices by a pump, with equally good results. The scheme of grouting in rock in the shaft bottom is shown in Fig. 9.

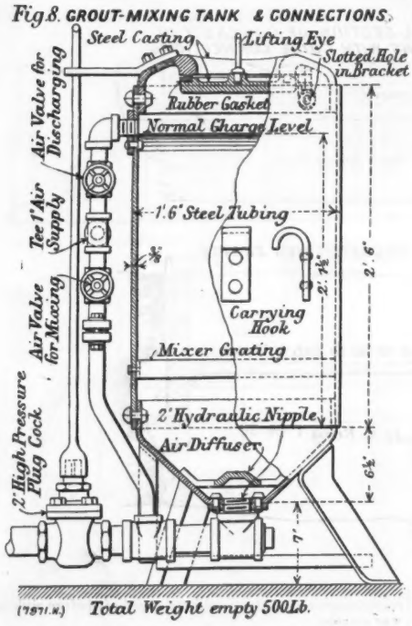
The pressure used in grouting varies greatly according to conditions. If you are grouting in solid rock, the higher the pressure the more efficient will be the grouting.

Usually with a grout tank you will use up to 125 lb. pressure. If you are using a pump, the pressure available is limited, of course, by the steam pressure and the ratio of the cylinders on the pump. In several cases on the Catskill aqueduct grouting was done under pressures as high as 500 lb., and my recollection is that in one or two cases a pressure of 600 lb. was used through the use of special equipment. Little high-pressure work is done in this section.

In grouting behind a shaft lining special care must be taken to gauge the pressure properly, and definite results can never be guaranteed. If the holes to be grouted are in a round shaft, or in round ends of a long shaft, they will, of course, stand more air pressure than in the flat side of a shaft, but it is practically impossible to force grout behind a lining with less than 20 lb. of air, and the possibilities of breaking a flat lining under even 20 lb. of air are very great. When grouting behind linings was first started, pans or blisters of tin were usually put against the rock rib where the water ran out when the lining was being poured, and a hole was punched in the tin from which a pipe led to the concrete lining form, and the grout was forced through this pipe. This is still done in many cases, but if it is possible to drive a pipe into the water-bearing crevice and caulk the rock seam so that all water will lead into the pipe, a much better grouting job can be done, for higher pressures can be used since there is not the area of lining over which the pressure of the grout can act.

The most successful grouting job in mine-shaft sinking

Fig. 8. GROUT-MIXING TANK & CONNECTIONS.



was done near Welch, W. Va., on the Tug River. Here a shaft that had been sunk for 10 years was still making 750 gallons of water per minute. When the mine changed hands improvements were planned and it was proposed that the shaft be lined with concrete, the lining to be designed so as to withstand pressure sufficient to grout the flow of water. We designed a heavily reinforced lining and used a very heavy H-beam section for buntons to be figured as struts. Back of the lining we placed corrugated iron, and canvas back of this, our idea being that when the grout was forced behind the lining it would fill the pores of the canvas and absolutely insure a water-tight job. When the grouting was finished, the shaft made, as nearly as we could figure, one quart of water per minute. I may add that the success of this job is decidedly unusual. Many equally heavy streams are encountered nowadays, but they are grouted in the sinking, and the necessity for heavy linings is avoided.

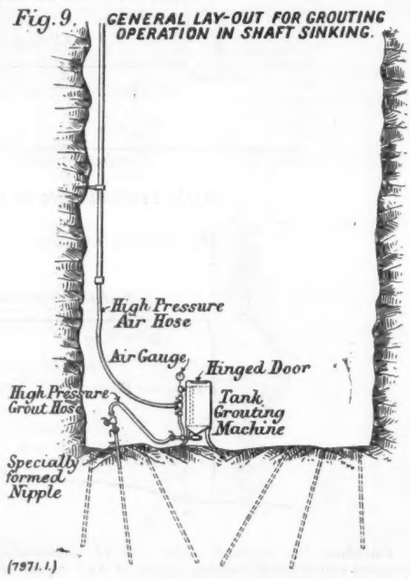
Grouting in slopes is a more difficult proposition. Since the strata are usually horizontal, the grout injected into the crevices must travel over a greater area to be effective. In water-bearing country it is wise to keep a test hole ahead pointed downward at a greater angle than the angle of the slope. If water is struck, more holes are drilled and grouted to refusal, but in driving a slope through a horizontal water-bearing crevice, it requires a long horizontal distance to get beyond the drainage area of that crevice, so that the sealing of water from a single crevice often requires several grouting operations. Each operation requires not only the time for the injecting of the grout, but a longer time to allow it to set before again shooting the face.

With the coal operator who is not familiar with the process of grouting the question of cost naturally arises when letting a contract. He is, of course, anxious to cut down the cost of his pumping, and any process or device which will save him dollars is interesting. Let us take a typical case. Assume the shaft to be 400 ft. deep and a stream of 200 gallons per minute encountered in the sinking. If this stream is not sealed he will have to pump it throughout the life of the mine. If his power averages 1 cent. per kilowatt-hour, it will cost him in the neighbourhood of 3,000 dols. a year. On a 15 per cent. basis, it will be found that he could afford to spend 20,000 dols. to seal off the water. While the rock in different sections of the country largely determines the grouting conditions, and hence the expense of grouting, the average cost of sealing off this quantity of water would not run over 3,000 dols. or 4,000 dols. I have been connected with jobs on which the total cost of grouting streams far in excess of 200 gallons per minute was not over 2,000 dols., and I know of no work on which a stream of this quantity has cost more than 5,000 dols. The operator could thus pay for his grouting in a year and save 3,000 dols. or 4,000 dols. a year afterwards.

Some engineers are of the opinion that in the mine development there is a possibility of catching the same water that is sealed from the shafts. There are cases where I believe this is possible, and, if the stream is directly above the coal, I can appreciate the hesitancy on the part of the engineer in his instructions to grout, although the absence of such a stream in the shaft, even though it should come out later in the mine, would be a very good thing for the shaft bottom. If the water is above a substantial streak of fire-clay or a thin vein of coal above the one being worked, I do not believe there is much likelihood of water penetrating the strata above the coal and flowing into the mine; at least until the ribs are drawn and the roof measures have sagged or fallen. Water usually flows in underground streams rather than simply lying in huge pools. It is very seldom that it is possible to pump dry a stream encountered in sinking. I am familiar with only one case where this was possible.

I have not discussed air-shafts as such, for the general details are, of course, the same as in hoist shafts. Stairs, if such are installed, are either of steel or wood. Steel makes the cleanest looking and strongest job, but a steel stairway is exceedingly difficult to paint effectively in the shaft. Yet of all details a stairway from a mine should be fireproof. In designing an air-shaft to pair with the hoist shaft which we have planned, I would include a stairway compartment, a hoistway to handle men, supplies, and cars of slate, the cage for this hoistway to be counter-balanced, and an airway for the fan to be separated from the hoistway by a masonry partition wall.

Fig. 9. GENERAL LAY-OUT FOR GROUTING OPERATION IN SHAFT SINKING.



The need for air-shafts at innumerable plants situated at points back in the mine is not half realised. I venture to say that fully two-thirds of the mine owners would find a tremendous saving in power costs if they would invest in air-shafts. Pumping air long distances under heavy water gauge will in most cases cost many times the interest on the capital required to put down an air-shaft. Most men would jump at the opportunity to invest in a safe 10 per cent. proposition, yet many coal operators hesitate to invest in air-shafts, even though such an investment would show a 20 per cent. or 30 per cent. return. That more attention is not given to the cost of ventilation is very strange indeed.

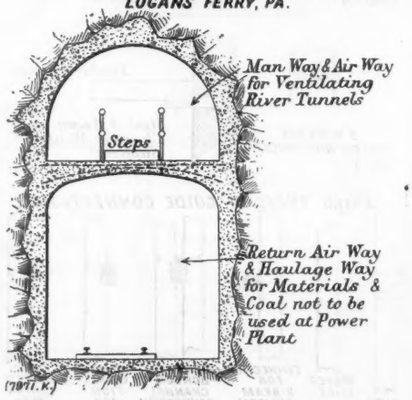
Shaft design and sinking in soft and running ground often require the use of caissons with the use of compressed air. In such conditions it is the most economical and in great depths the only practical method of reaching rock. The depth determines the thickness and reinforcement of the shell, at the bottom of which is usually attached a steel shoe or cutting edge. The inside dimensions of the shaft are usually 12 in. or 15 in. larger than the standard shaft size, and in exceptionally great depths this allowance is usually more. This is done to take care of the possibility of the caisson getting out of plumb as its sinking progresses.

As the material is removed from the inside, the shell sinks and sections are added to the top. If the quantity of water becomes too great for pumping when the material is handled by hand, or if boulders or other obstructions prevent further work with dredge buckets through the water, it is necessary to put in a diaphragm or deck and work by hand under compressed air. One of the greatest difficulties in deep caissons of the size required for shafts is the work and expense required to straighten a shaft after it has shifted out of plumb. The sealing of a caisson in rock so that the compressed air can be released and the deck removed is a most expensive and particular detail, and at great depths requiring high pressures, and consequent short expensive shifts of men, the job is particularly costly; and, while shaft caisson sinking is expensive, slope work through running ground or quicksands is practically prohibitive in cost.

There have been few changes in the last ten years in the general scheme of shaft sinking. The procedure, as is well known, consists in drilling the rock usually with a small type of compressed-air drill with holes so placed as to shoot out a sump or cut 8 ft. or 10 ft. deep out of the bottom of the shaft; and, when this has been mucked out, to drill and shoot the remaining section of the shaft or benches in the same manner. When these benches have been completely mucked out the procedure is repeated. Care must be taken in the placing and the loading of the hole so that as little damage as possible is done to the concrete lining and buntons above. Expert rock men can very often drill and shoot without bending or breaking a bunton by gauging just the right amount of powder necessary simply to break up the particular kind of rock in which they are working. The nature of the rock—that is, whether it will disintegrate under the action of air and water—determines the depth which can be sunk before lining is necessary, for it is, of course, unsafe for men to work underneath rock which will disintegrate and scale from the sides of the shaft above.

For lining purposes the contractor will carry 40 or 50 vertical ft. of concrete forms, which are usually made in sections. When it is decided to concrete, the muck is levelled off in the bottom of the shaft and sections of forms, designed according to the plan of the shaft and usually 5 ft. or 6 ft. in height, are bolted together to make a complete ring. The bunton ends or buntons are placed in notches set in the forms, and the space between the rock rib and the form is filled with concrete. This process is repeated until the stretch of concrete is joined to the old concrete above. As soon as the stretch of concrete is completed, the muck in the bottom of the shaft is taken out and the concrete forms are removed, when the process of sinking is again resumed. That blasting so soon after concrete is placed does not shatter the concrete seems remarkable, but I have never seen cracks from this cause.

Fig. 10. DOUBLE-DECK SLOPE FOR SPRINGDALE MINE, WEST PENN POWER COMPANY, LOGANS FERRY, PA.


Man Way & Air Way for Ventilating River Tunnels
Steps
Return Air Way & Haulage Way for Materials & Coal not to be used at Power Plant
(7971.K.)

We cannot close any discussion of shaft design and sinking without giving a few words to slopes, for in the last few years and at the present time they are being very favourably considered for coal under 200 ft. in depth both for haulage and for manways. Conveyors, both of the rubber belt and steel apron type, have been very successful in moving big tonnages at a low cost. For rubber belts a slope with a maximum of 33 deg. has been used, but I have heard users of the 30-deg. slope say that they are too steep. Slopes for manways and supplies are usually sunk on a 25 per cent. grade. Slope linings of concrete depend upon the roof's span for their design. Openings over 15 ft. or 16 ft. wide are expensive to construct in localities where there is soft rock or unusual depth of earth over the rock. Any slope is difficult to sink in soft earth and extravagantly expensive in running ground, as has been noted. In ordinary earth it costs about twice as much per lineal foot to sink as in solid rock because the earth is harder to remove than blasted rock, and timbering with sets closely spaced is required to prevent the roof and sides from caving.

In order to overcome the difficult construction of a very wide slope in localities where there is excessive earth or soft rock, two companies in this field have constructed double-deck slopes similar in design to Fig. 10. While expensive to build, one such slope is cheaper than two slopes having the same capacity, or than one slope of the same area with the compartments side by side Practically all concrete-lined slopes to-day have arched roofs from 12 in. to 18 in. thick. The side walls should be 12 in. to 15 in. thick. Arched slopes are naturally the strongest and do not as a rule require reinforcement. The additional area in a slope with an arched concrete roof over the area provided by a rectangular section is always to be desired for ventilation and head room.

NEW DEVELOPMENTS IN ELECTRIC TELEMETERS.*

By O. S. PETERS and R. S. JOHNSTON.

Summary.—As a result of development work at the U.S. Bureau of Standards, there are now available remote reading and remote recording instruments suitable for measuring rapidly varying pressures, stresses and strains. These instruments depend for their operation upon the well-known pressure-resistance, or corresponding displacement-resistance, characteristic of a stack of carbon plates, a mounting for which has been devised that gives sufficient stability of resistance and freedom from hysteresis effects for many engineering measurements. Means have also been provided for giving a linear characteristic to the practical form of instrument.

Important applications so far made have been to the measurement of stresses in airplane stay cables during flight, of strains in airship girders during construction tests, of strains in airship girders and plate girder made and instruments for several purposes developed with sufficient accuracy and stability for many kinds of engineering measurements.

For their operation these instruments depend upon the well-known pressure-resistance, or corresponding displacement-resistance, characteristic of a stack of carbon plates. Heretofore, attempts have been made to utilise this characteristic of carbon for making engineering measurements, but without success because of erratic behaviour of the resistance of the carbon stack, hysteresis effects, and also the non-linear relationship existing between displacement and resistance. In the present work, the resistance of the stack has been stabilised, and changes of resistance with changes of pressure made reproducible, by mounting the stack in a frame in such a way that it is always under a considerable pressure, and confining the range of change of pressure within comparatively narrow limits. The pressure on the stack is also applied axially, and great care is exercised in assembling in order to make transverse forces on the carbon contacts as small as practicable.

Hysteresis effects, or those effects which cause the resistance of the stack corresponding to a given pressure to be higher or lower, depending upon whether the pressure has been approached from a higher or lower value, have been made negligible by using a mounting frame without mechanical joints, it having been found by experiment that the cause of the hysteresis lay in these joints rather than in the stack itself. Care is also exercised to prevent any part of the frame from being

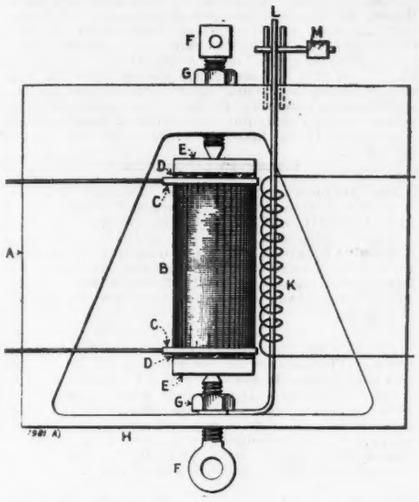


FIG. 1. MOUNTING FRAME FOR SINGLE STACK OF CARBON PLATES.

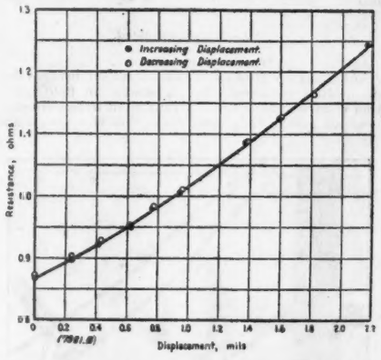


FIG. 2. DISPLACEMENT-RESISTANCE CURVE FOR SINGLE STACK OF CARBON PLATES (CARBON-RESISTER NO. 5).

small amount by the force or displacement under measurement, the resistance being measured by means of the contacts, C. K, L and M are not a part of the resister, but an auxiliary reflecting device for calibrating purposes, the mirror, M, being rotated by deflection of spring H, through rod L, K being a magnetising coil to make the roller stick.

In Fig. 2 is shown a typical displacement-resistance curve obtained from a single stack resister of the type described above. The magnitude of the change of resistance is of particular interest, it being approximately 46 per cent. for a change of length of the stack of 0·00217 in. Attention is directed to the coincidence of increasing and decreasing values; that is, the hysteresis effect in the stack itself is negligible, and it may also be stated that after the stacks are properly aged they will retain their values of resistance for long periods under ordinary handling with changes not exceeding 1 per cent.

Electrical Circuits for Indicating or Recording Measurements.—In order to utilise the change of resistance of the two stacks of rings, which, as stated above, are incorporated in each instrument, they are connected in a

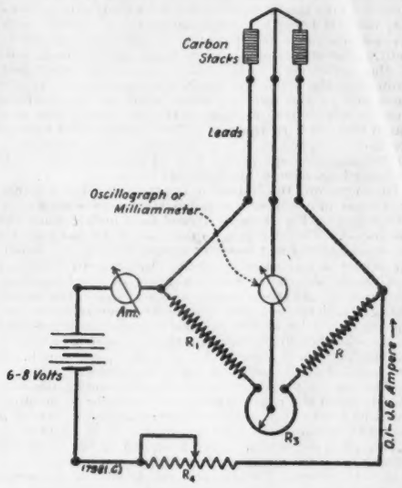


FIG. 3. TWO STACKS OF CARBON PLATES IN WHEATSTONE BRIDGE CIRCUIT.

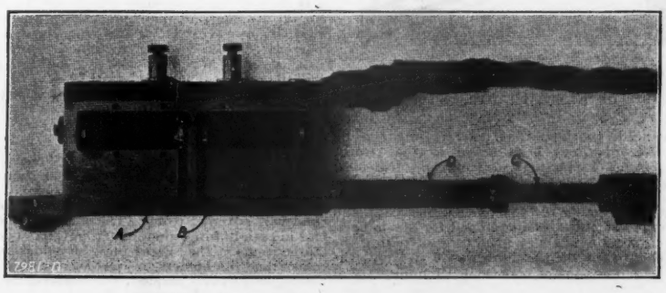


FIG. 4. STRAIN INDICATOR FOR RIGID MEMBERS.

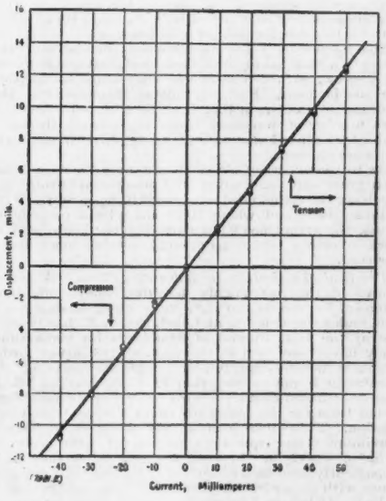


FIG. 5. CALIBRATION CURVE FOR CARBON-RESISTER TYPE OF STRAIN INDICATOR.

during laboratory tests, and of the pull on the pressure arms of dynamometers.

The advantages obtained from the use of these instruments are as follows:

1. The remote reading feature, which enables records to be taken in places that are inaccessible during tests.

2. Simultaneous readings or records on a single strip of paper may be taken of phenomena occurring at a number of widely separated points.

3. True reproductions of vibratory strains and pressures may be obtained up to several hundred cycles per second; and

4. Great savings of time can be effected where large numbers of strain or pressure measurements are to be taken in field or laboratory tests.

Development work has been in progress for a number of years at the U.S. Bureau of Standards on a line of strain, stress and pressure gauges with the view of making them remote reading and remote recording, and at the same time adapting them to the measurement of displacements and forces that are rapidly varying in value. Instruments capable of accomplishing these purposes would have numerous advantages over those now in use. The latter, in general, are suitable only for measuring values that are relatively steady, and instead of being remote reading or recording, must be read at the point of measurement, which in many cases, as in field work, may be inaccessible. Satisfactory progress has been stressed beyond the elastic limit of the material by the pressure applied.

The non-linear characteristic has been overcome by mounting two stacks of plates in each instrument in such a way that the resistance of one is decreased and the other increased by the force or displacement under measurement. By experiment, the cumulative change of resistance of the two stacks has been found to be proportional to the change of displacement or pressure, with the ultimate result that an instrument with substantially a linear calibration curve is obtained.

THE APPARATUS AND ITS OPERATION.

General Form of Mounting for Single Stack.—In Fig. 1 is shown a mounting frame for a single stack of plates which embodies the essential elements necessary to secure the stability of resistance and freedom from hysteresis effects described above, and a form which has been used extensively for testing different kinds of carbon. A, is a steel frame cut from a solid piece of metal; G, a stack of carbon plates, or rather annular rings about fifty in number; C, a pair of brass contact discs for making electrical contact with the carbon rings; R_3 a pair of mica discs insulating the carbon from the frame; and E, a pair of tempered steel end pieces cupped axially to receive the round-pointed tempered steel setscrews F, which are threaded into the frame and held rigidly by the lock nuts, G. With a stack of rings assembled between the set-screws, the pressure is adjusted to a predetermined value and the lock-nuts drawn up to prevent any further movement of the screws in the thread. Part H functions as a stiff spring which is deflected a Wheatstone bridge circuit as shown in Fig. 3, the two branches of which consist of the carbon stacks and leads in series on the one hand, and the resistances R_1, R_2 and R_3 on the other, R_1 and R_2 being fixed resistances and R_3 a slide wire resistance by means of which a fine degree of balance of the bridge is obtainable. The bridging instrument may be a milliammeter, galvanometer or oscillograph element, and is connected between the midpoint of the carbon stacks and the movable contact on R_3. The bridge is energised from the battery at the left, the current being kept at some suitable constant value by means of the variable resistance R_4.

In use, the bridge is first balanced. Then as change takes place in the resistance of the carbon stacks the balance is upset and the bridging instrument deflected. As long as the current taken by the bridging instrument is small in comparison with the total current in the bridge

* Paper read at the meeting of the American Society for Testing Materials, at Atlantic City, June 25 to 29, 1923.

circuit these deflections will be proportional to the total change of resistance of the stacks, and the latter being proportional to the force or displacement under test, the ultimate result is a uniform scale reading of the bridging instrument. This enables calibration directly in thousandths of an inch in the case of strain gauges, or total load or pounds per square inch in the case of stress or pressure gauges.

The leads from the carbon stacks to the other portion of the bridge circuit may be of almost any length, some of No. 16 copper wire 100 ft. long having been used successfully. This enables simultaneous readings or records at a number of widely separated points by a single operator, the fixed resistances and bridging instruments being combined in one suitable panel. Groups of as many as twelve have been used, and larger groups could be assembled if necessary.

Strain Indicator for Rigid Members.—In order to measure strains in rigid structural members, a pair of carbon resisters is incorporated in a device the details of which are shown in Fig. 4. Here A is a frame formed from a solid piece, preferably of nickel steel, of which B is a cantilever integral with the frame and having a relief cut near its fixed end. Part C is a rod which is threaded into the cantilever and drawn up with a lock-nut, the rod being free to move in the guide D which fits closely enough to prevent appreciable lateral movement. The stacks of rings are assembled on each side of the cantilever, with a three-conductor wire lead connecting the stacks to the indicating device. At the outer end of the rod is a block with two nuts which serve to adjust the position of the cantilever, and also clamp the block to the rod. The span covered by the instrument shown is 8 in., although others have been made ranging in span from 2 to 24 in., and having full scale readings from 0·002 to 0·024 in.

In operation, the indicator is attached to a member by means of clamps, the sharp steel points shown at either end in Fig. 4 being forced into punch marks in the metal. The clamping is done with the nuts at the outer end of the rod loose, after which these are drawn up in such a way as to bring the cantilever to its initial position as shown by a zero reading of the indicating instrument. As stress comes on the member, the length changes and the rod and cantilever move relatively to the frame. Part of this displacement is communicated to the stacks of rings, changing their resistance and causing deflection of the bridging instrument, which, as indicated above, is proportional to the strain.

The force required to operate the instrument depends largely upon the resistance of the cantilever to bending, but this need not exceed 10 lb. as a maximum, which is a small portion of the total stress usually involved.

A typical calibration curve is shown in Fig. 5, which indicates the performance in both tension and compression with reversal of stress, and also the linear characteristic resulting from the use of two stacks of plates as compared with Fig. 2, where a single stack was used. The hysteresis effects found in present equipment do not in any case exceed 4 per cent. of the full range of the instrument, and in the majority of cases are less than 2 per cent. At the same time they are of such a nature that correction can be made for them if it is desirable.

The method of calibration consists in clamping the gauge to a base having one fixed block and one movable by a screw, with a micrometer microscope to measure the displacment. For any given displacement the bridging instrument in Fig. 3 can be adjusted to read an even number of divisions, thus doing away with multiplying factors, and making the readings direct in whatever units are chosen.

As to the accuracy obtainable, it may be stated that with great care, and where uni-directional strains are involved, the errors need not exceed 0·5 per cent. With ordinary care and where there may be a reversal of stress, the errors need not exceed 2 per cent., and in work involving vibrations or unfavourable conditions 5 per cent.

Practical Application in Laboratory Tests.—A set of twelve of the instruments described above originally intended for use on the U.S. Navy Fleet Airship No. 1 now under construction at Lakehurst, N.J., has been in use at the U.S. Bureau of Standards for some time. They have been used in the tests of 143 lattice girder members which were full-size duplicate parts of the duralumin frame construction of Fleet Airship No. 1, and on fourteen column test specimens of the investigational tests for the Delaware River Bridge Joint Commission. These instruments were designed to have a maximum range equivalent to a total deformation in 8 in. of 0·012 in. In both the test series they have consistently been used considerably beyond their designed range with no noticeable effect upon their calibration.

In the Delaware River bridge tests, a most interesting comparison as the result of their use is that which shows the relation between longitudinal and transverse strains on the web of the column section tested. The location of the instruments on the 1-in. web plate at the mid-length of the specimen is shown in Fig. 6 and the log sheet readings are given in Table I. The consistency of the operation of the instruments is nicely shown by these readings. A study of the data of the tests indicates that the load in the column section was not uniformly distributed throughout the length of the member until a stress of 15,000 to 20,000 lb. per square inch had been applied—the strain measurements at the ends and the early development of Hartman lines at the ends being duplicating evidence of this fact. The strains measured at mid-length, therefore, would not be in agreement with what might be expected for the assumed uniform distribution of stress. The modulus would therefore be high. As loading is continued and buckling of the web proceeds, the longitudinal strains would be somewhat excessive and modulus computations show a lower modulus. This phenomenon is indicated in the deformation shown for instrument No. 2. It is of interest to note the uniformity of the relations of transverse to longitudinal strain throughout the test, as exhibited by two similar instruments in simultaneous operation.

TABLE I.—*Tests on Plate Girder Web. Delaware River Bridge Joint Commission.*

Applied Load, lb. per sq. in.	Total Deformation in 8 in., in		Ratio, Transverse Strain to Longitudinal Strain
	Instrument No. 2 (Longitudinal Strain—Compression)*	Instrument No. 10 (Transverse Strain—Tension)*	
0	0·0000	0·0000	0·000
5,000	0·0012	0·0002	0·167
10,000	0·0027	0·0005	0·185
15,000	0·0042	0·0009	0·214
20,000	0·0056	0·0012	0·214
22,000	0·0061	0·0014	0·229
24,000	0·0068	0·0015	0·220
26,000	0·0073	0·0017	0·233
28,000	0·0080	0·0018	0·228
30,000	0·0088	0·0020	0·227
32,000	0·0096	0·0022	0·229
34,000	0·0102	0·00225	0·220
36,000	0·0117	0·0025	0·214
38,000	0·0120	0·0027	0·225

* Last figure estimated.

OTHER APPLICATIONS.

Field Tests on Bridges.—Field tests on bridges have been limited to testing the apparatus in field service rather than analysing the distribution of stresses in structures, but enough has been done, and the design sufficiently advanced, to show that good results can be obtained. Records have been taken of the strains occurring in some of the tension members of a steel truss bridge while trains were passing. Six traces were taken simultaneously with an oscillographic recorder, four being gauge records, one a time record, and one inactive. The outfit was equipped for six gauges, but only four were available at the time of taking the records. The width of the film was 6 in., and the calibration in pounds per square inch per millimeter of deflection.

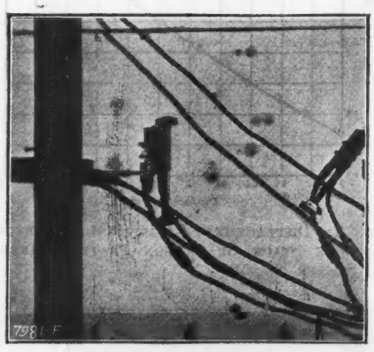


FIG. 6. TELEMETER GAUGES CLAMPED TO WEB OF PLATE GIRDER.

The vibrations recorded ranged between two cycles and 100 cycles per second, the amplitude of the higher frequencies being insignificant, of course, as compared with that of the lower frequencies. With vibrations of this character, repeated tests have shown very little effect on the calibration, and as the free period of the different parts of the apparatus which could introduce sympathetic vibrations was adjusted above 300 cycles per second, or three times the highest frequency recorded, it appears that the deflections must be proportional to the strains.

The entire equipment for the field outfit may easily be carried in a touring car or light truck.

Airplanes and Airships.—One of the first applications was to the measurement of stresses in airplane stay-cables during flight, a recorder having been developed that enables twelve records to be taken simultaneously during manœuvres of various kinds. A similar application has been made to airships, although no records or readings during flight have so far been taken, the tests having been confined to work during construction.

Dynamometers.—A carbon resister device for recording the pull on the pressure arm of a machine for testing brake band material has been in service for some months with good results, giving steady readings, and permitting one operator to care for several machines instead of one, as would be the case if a spring balance were used.

Pressure Gauges.—Experimental applications have been made to the measurement of pressures ranging from a few millimetres of mercury to 40,000 lb. per square inch. More work remains to be done in this as well as other directions, but the indications are that pressure gauges can be made that will give satisfactory results, and that will be especially valuable where records are desired of rapidly changing pressures.

CATALOGUES.

Wood Planers.—A little book with much practical information about the thin planing knives used on the rotary cutters for planing wood has been sent to us by Messrs. Drabble and Sanderson, Limited, Sheffield, who make and finish these tools. The grinding of the blades suit work on various kinds of wood, the proper balancing of cutter blocks and knives and the finishing of the cutting edges after assembly are all carefully explained in notes on the causes of uneven and inefficient cutting.

Electric Lamps.—The second of the pamphlets entitled "The Problems of Artificial Illumination," prepared by the Research Laboratories of the General Electric Company, Limited, has been devoted to the Osglim discharge lamp. In this type of lamp the light comes from the ionisation of the atoms within a globe which contains a gas, which is mainly neon, at a very low pressure. The discussion of the actions taking place which result in the production of light forms a very interesting and absorbing story.

Diamond Tools.—A catalogue of diamond tools from Messrs. A. Shaw and Sons, 60, Spencer-street, Clerkenwell, London, E.C.1, contains illustrations of over twenty tools for use in the slide rest; and also some for hand working, including a special tool for cutting glass tubes such as boiler gauge glasses. The diamond is used largely for truing up grinding wheels, and to an increasing extent for turning soft materials such as vulcanite, mica and fibre compositions, against which it maintains its edge better than high speed steel. Prices are stated.

THE TELEPHONE IN DENMARK.—Denmark has now worked its way to the premier place in Europe in regard to the ratio of the number of telephones to the inhabitants. A report states that at the end of 1922 there was in Denmark a telephone for each 12 inhabitants, in Sweden 16, and in Norway 21. The aggregate revenue of the Danish companies was for 1922, 40,250,000 kr., and 16,250,000 kr. were applied to extensions and new installations.

CATALOGUES FOR NORWEGIAN GOVERNMENT DEPARTMENTS.—The Commercial Secretary at Christiania has forwarded to the Board of Trade a list of certain Norwegian Government Departments who are desirous of receiving catalogues from British firms. The list, which sets out the nature of the requirements of these Departments, can be consulted by United Kingdom firms interested on application to the Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1.

SWEDISH SHIPBUILDING.—The Göta shipyard in Gothenburg has in hand orders which will keep it fully employed for a considerable period, and all the company's slips are full at present. Some little time ago an order was secured for two motor vessels for American owners for the Pacific trade and from the Grängesberg company for 15 motor vessels for ore transport. Last year 54 per cent. of Sweden's production of tonnage was built in this yard. When the new floating dock is finished it will be able to accommodate vessels of 18,000 tons. The dimensions are 676 ft. length, 82 ft. breadth and 26 ft. depth, and it is so constructed that it can be divided into two parts.

AMERICAN WORKMEN'S SHARES.—The United States Steel Corporation has offered 60,000 shares to its employees at a price of 107 dols. per share. The number of shares each worker may buy depends upon his wages and varies from 1 to 16. The shares are not to be paid for in cash but in deductions from wages over a period of three years. The shares may be sold, but in order to encourage the holders to keep them as long as they are in the company's employ, the holders, after five years, receive an annual premium of 5 dols. per annum provided they have been in the company's employ the whole time. Should a shareholder wish to terminate his association with the scheme he receives the amount paid with 5 per cent. interest. This is not a new departure but has been going on for a number of years, and at the beginning of this year shares to the value of 18,000,000 dols. were held by employees.

GERMAN ENTERPRISE IN SOUTH AFRICA.—We read in *The South African Mining and Engineering Journal*, with reference to a woollen factory at Harrismith, that this is a spacious, airy and well-lighted building, occupying about 4 acres adjacent to the railway line, equipped with an installation of wool-manufacturing machinery of the very latest pattern. The visitor experiences an initial disappointment when he finds that the plant, from the 500-h.p. tandem compound condensing engine, driving the dynamo which generates the current on which the factory is run and lighted, down to the smallest detail of the spinning mules and weaving looms, is of German make. Moreover, the factory is under German management and technical direction, some 13 experts having been brought over with the plant. But this circumstance is explained by the fact that the lowest British tender was 150,000*l.*, whilst the German makers' figure was 33,300*l.* Added to this was 19,209*l.* for additions, handling, transhipment and rail carriage. The complete plant has been erected at Harrismith for 52,000*l.* The land, factory, power station, wool-shed, stores, &c., cost 46,173*l.* In the placing of contracts, account had also to be taken of the fact that whilst the German firm could promise delivery in ten months, the Americans wanted four years and the British stipulated two years for the completion of the work.